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REPORT OF ACTIVITIES Second Quarter 1994

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SOUTHWEST FISHERIES SCIENCE CENTER

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Information Technology Services Chief ..... *Dorothy D. Roll*
Executive Officer ..... *Sherrie L. Rasmussen*

LABORATORIES & DIVISIONS

Antarctic Ecosystem Research Group, Chief ..... *Rennie S. Holt*
La Jolla, California
Coastal Fisheries Resources Division, Chief ..... *John R. Hunter*
La Jolla, California
Marine Mammal Division, Chief ..... *Robert L. Brownell, Jr.*
La Jolla, California
Honolulu Laboratory, Director ..... *R. Michael Laurs*
Honolulu, Hawaii
Pacific Fisheries Environmental Group, Chief ..... *George W. Boehlert*
Monterey, California
Pelagic Fisheries Resources Division, Chief ..... *Gary T. Sakagawa*
La Jolla, California
Tiburon Laboratory, Director ..... *Alec D. MacCall*
Tiburon, California

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Editor: Connie Blair
Layout: Roy Allen

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1993/94 Field Season Data Analyzed

During April-June, the staff of the Antarctic Ecosystem Research Group (AERG) analyzed data collected during the 1993/94 field season and produced a number of papers reporting their findings. Many of the papers were completed as part of the Antarctic Marine Living Resources (AMLR) Program's participation in the upcoming annual meetings of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), in particular, the Working Group on Krill (WG-Krill).

AERG's Fishery Biologist Roger Hewitt and Ocean Acoustics Engineer David Demer wrote several papers for the WG-Krill meeting. One paper, "An attempt to derive a composite index of abundance from acoustic surveys and fishery data," is the result of collaboration between Hewitt, Demer, and Victor Marin, a Chilean scientist from the Universidad de Chile de Santiago. The acoustic data were collected during the 1992 AMLR cruise in the vicinity of Elephant Island and the fishery data were obtained from a Chilean krill trawler that operated in the same area.

A second paper by Demer and Hewitt, "Distribution and abundance of Antarctic krill in the vicinity of Elephant Island during the 1994 austral summer," reports on krill biomasses estimated from data collected during the four acoustic surveys of the 1994 AMLR cruise. These biomasses were compared to 1992 and 1993 AMLR survey data. Average krill densities for 1993/94 were the lowest of any observed during the last 5 years of AMLR surveys in the Elephant Island study area and one-fifth of the 1990-92 density.

In a third paper, "In situ target strength measurements of Antarctic zooplankton *Euphausia superba* and *Salpa thompsoni* at 120 kilohertz (kHz) and 200 kHz, corroboration of scattering models, and a statistical technique for delineating species," Demer and Hewitt use in situ target-strength measurements of these two species, which are the most dominant zooplankton species in the Elephant Island area, to show that salps fit a fluid sphere model and krill fit a deformed cylinder model. These two models are then used to develop a new method for acoustically identifying and delineating species. Delineating krill from other animals that coexist in the same environment is necessary to provide accurate assessments of krill distribution and abundance.

In his last paper, Demer teamed up with Linda Martin, Woods Hole Oceanographic Institute, on "Zooplankton target strength: volumetric or area dependence?" which discusses the dependence of target-strength data of various zooplankton collected at frequencies of 200 kHz, 420 kHz, and 1 megahertz on animal volume versus animal cross-sectional area.

Also to be tabled at the Working Group meeting for the CCAMLR Ecosystem Monitoring Program is the 1993/94 AMLR field season report, compiled and edited by Biologist Jane Rosenberg, AERG. The report, which fulfills a variety of post-cruise obligations, includes her summary of research conducted during the 1994 cruise in the waters surrounding Elephant Island and at field stations on Seal Island and Palmer Station. Detailed summaries written by the AMLR Program's principal investigators are also included.

In addition to papers prepared for the upcoming CCAMLR annual meetings, Operations Research Analyst Stephanie Sexton, AERG, has completed a draft of a paper titled "Volume visualization for marine ecosystem modeling: interactions between Antarctic krill and the environment." The paper will most likely be submitted to *Deep Sea Research*. It evaluates the feasibility of using volumetric analyses for data sets that are continuous with space (for example, temperature) and those that are patchy (for example, krill).

Scientists in the AMLR program also submitted a series of papers to the *Antarctic Journal of the United States* for the 1994 review issue. Rosenberg, Hewitt, and AERG Chief Rennie Holt wrote a lead article for the series that gives a basic review of the AMLR program and the 1993-94 field season, and other AMLR researchers wrote articles describing their particular research components.

AERG's Fishery Biologist George Watters spent much of April-June coordinating and assisting in the placement of a U.S. observer aboard a Russian long-liner fishing vessel. The vessel fished in the vicinity of South Georgia Island for Patagonian toothfish, *Dissostichus eleginoides*. Later, Watters debriefed the observer and outlined report requirements for the collected fishery data. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Economists Analyze Fishing Vessel Owners' Ability to Change Unregulated Economic Factors Under the Current License Limitation in the Pacific Coast Trawl Fishery

Former student worker Jeffrey Lee, University of California, San Diego, and Industry Economist Dale Squires have completed an analysis of the potential to substitute one economic input (for example, capital, labor, or energy) for another under license limitation in the Pacific coast trawl fishery. A synopsis of their analysis follows:

License limitation was recently implemented for groundfish trawlers by the Pacific Fishery Management Council. License limitation programs such as this one restrict fishing effort to counter the loss of economic rents (profits) and stock depletion that can occur in open-access fisheries. Typically, these limitation programs fix only one or just a few of the economic inputs that comprise effort (capital, labor, energy). But because effort is multidimensional, comprised of individual economic inputs that do not remain in fixed proportions, limits on one of effort's components invites expansion of the remaining unregulated inputs. Expansion of the unregulated inputs, called "capital stuffing," can lead to expansion of fishing effort and loss of any economic rents that might otherwise be generated. For example, if vessel size is limited, one might expand fishing time (that is, fuel costs) to increase or maintain fishing power.

In response to the potential for "capital stuffing," there have been proposals to create supplementary regulations in the new license limitation system. Restrictions on license-holding vessels, such as gear limits, length limits, and trip duration limits have been suggested. These supplementary restrictions would hopefully impede subsequent increases in effort. In addition, to limit expansion of fishing power, vessel lengths would only be increased beyond a narrow range by the purchase and consolidation of permits for other vessels. For example, someone wishing to construct and fish with a vessel larger than that currently owned would have to purchase the license of another vessel and combine it with the existing license in order to have sufficient permissable length under license. The purpose of this study was to address these issues by assessing the individual fishing vessel owner's ability to change his or her mix of unregulated economic inputs under license limitation in the Pacific coast trawl fishery.

The potential for capital stuffing was evaluated by use of an economic production function. The production function models the vessel's harvesting process as the application of economic inputs to the fish stock to yield a flow of catch.

The general production function used to model the production technology can be specified as

$$Y = f(K,L,F;B,T) \qquad (1)$$

where Y represents output (catch) in metric tons, K denotes capital, L is labor, F is fuel consumption, B represents biomass of the resource stock, and T denotes technological factors such as the state of technology of the boat's equipment.

Capital is a multidimensional concept, including engine horsepower, net type and size, vessel electronics, and other gear and equipment (for instance, winches). Because a single index of capital does not exist, boat length (registered length overall in meters) serves as a proxy variable. It was chosen because the other dimensions of capital were found to be closely correlated to length, and length (as opposed to a measure of vessel volume such as gross or net registered tons) is the measure most commonly used by fishers and it is the measure by which vessels are sold.

Labor is represented in the model by the flow of labor services: crew size (including captain) multiplied by weeks fished in the year. Fuel consumption is represented by liters of fuel consumed per year. Variation in fish stock abundance is represented by a technology shift variable, that is, a technological constraint, rather than as an input under the control of individual firms. Hence, it is represented by annual dummy variables, which are zero and one (binary variables), with a value of one for a given year (for example, 1987) and zero in all other years (Table 1).

Lee and Squires adopted a random effects model to explicitly incorporate panel (pooled cross-section [individual vessel observations for a given year] and time-series) data. Using this approach, they also explicitly incorporated fishing skill and motivation of the crew and captain. These qualities or attributes, which are unobserved, can make an important contribution to production. Biased coefficients can also result from omitting these differences in how the vessel is managed.

Table 1. Descriptive statistics of fishery data used in analysis of input substitution possibilities under license limitations in the Pacific coast trawl fishery. Data collected 1986-89.

Variable	Mean	Standard Deviation	Minimum	Maximum
Vessel gross tonnage	74.39	40.64	10.00	169.00
Vessel length	59.33	14.36	28.00	86.00
Crew size	3.01	0.35	2.00	4.00
Weeks fished	30.46	7.57	9.00	44.00
Fuel cost[1]	$15,181.00	$18,333.00	0.00	$97,000.00
Total catch (metric tons)	559.55	900.30	2.20	5110.00
Total revenue	$36,975.00	$53,452.00	$1.80	$204,500.00

Note: Sample means of annual data taken from 26 vessels and 83 total vessel-years.

[1]Representative of fishing time.

Annual dummy variables for 1986, 1987, and 1988 account for time-specific effects, which are primarily changes in resource abundance but also changes in the state of harvesting technology (see Table 2). Dummy variables used in this model represent resource abundance, which may be interpreted as a technological constraint that affects the harvesting technology.

Table 2. Estimated parameters used in analysis of input substitution possibilities under license limitations in the Pacific coast trawl fishery. Data collected 1986-89.

Variable	Cobb-Douglas Random Effects Model
Constant	-0.2370 (0.2903)
Dummy variable for 1986	-0.0321 (0.5144)
Dummy variable for 1987	0.3773 (0.3734)
Dummy variable for 1988	0.6590 (0.2963)
Labor	0.6626 (0.2949)
Fuel	0.2896 (0.1577)
Capital	2.8348 (0.8547)
R^2	0.58

Note: Values are based on ordinary least squares. Correction made for first-order serial correlation. Translog point of approximation at geometric mean. Standard deviation in parentheses. R^2=coefficient of determination. Dummy variables described in text.

Lee and Squire's analysis covers 1986 to 1989. The data set encompasses costs, revenues, landings, and fishing time for 83 vessel-years from 26 trawl vessels that participated in the Pacific coast groundfish fishery in Washington, Oregon, and northern and central California. The data forms an unbalanced panel (pooled cross-section and time-series) data set since the number of time-series observations are not always the same for each cross-section.

Through hypotheses testing of a translog, a CES, and a Cobb-Douglas functional form, Lee and Squires selected a particular form of the production function, the Cobb-Douglas, as best fitting the requirements for their model. This form has constant elasticities of substitution equal to one. (The elasticity of substitution measures the degree with which two inputs in a production process can be interchanged when producing a given level of output. The larger the measured value, the greater the ease of substituting one input for another. If the inputs are substitutes, an increase [decrease] in one input requires a corresponding decrease [increase] in the use of the other).

The uniform substitutability among all economic inputs suggests the potential for capital stuffing as vessel operators substitute unregulated inputs for the restricted vessel length to increase the productive capabilities. The current license system fortunately restricts vessel size expansion except through consolidation of licenses (which removes vessels from the fishery).

The selection of a random coefficients model over a fixed-effects model by hypothesis testing (the Hausman test) suggests that the random intervessel differences are uncorrelated with the other explanatory variables of capital, labor, and fuel. This suggests that differences in vessel-level management—"skipper skill"—are not directly correlated to a skipper's management of these

standard determinants of productive capabilities. Rather, as expected, skipper skill is more directly related to finding fish, dealing with unforeseen events, handling inclement weather, and so forth.

The measure of scale economies, conditional upon resource abundance, is 3.79, indicating increasing returns to scale. That is, a one percent increase in all economic inputs increases total catch by 3.79 percent, given a constant resource stock. This result also implies that unit cost declines with increases in inputs, given a constant resource stock and state of technology. Steaming time (time spent traveling to fishing grounds) to a large extent represents a "fixed cost" to vessels. Hence, additional time on fishing grounds lowers the overall production cost by spreading this unavoidable fixed cost of steaming time over larger catch levels, reducing unit costs.

The role of fishing skill in determining productive capabilities has important implications for license limitation programs. To the extent that the determinants of productive capabilities are related to fishing skill and not only the economic inputs in themselves, a buy-back of active vessels will not in itself necessarily reduce productive capabilities. Also, managerial abilities are not directly observable and are beyond the control of fishery managers, limiting the options of these regulators to directly regulate catching power.

Growth in productive capabilities through catch-per-unit effort also increases effective effort, and like managerial ability, is very difficult to control by regulators in a license limitation program. Increased use of vessel electronics (for example, fish finders), improved design of gear and equipment, exit of less productive vessels and skippers, and the like, all enhance productive capabilities. Differential adoption and usage of these technological innovations can also contribute to the observed inter-vessel differences and may compose an important part of the intervessel residual attributed to managerial ability, that is, in some sense, skipper skill cannot be explicitly measured.

Productivity growth (catch-per-unit effort) in the Pacific coast groundfish trawl fishery over the period 1981-1989 raised effective effort an average of 2.79 percent per year (see Squire's "Sources of growth in marine fishing industries," *Marine Policy*, 1994, Volume 18). The license limitation program's effectiveness in raising rents (profits) and restricting catches could be hampered by this growth in effective effort without compensating vessel reductions or ancillary regulations such as trip limits.

In summary, the universal substitutability among economic inputs implies that unregulated components of fishing effort could potentially expand. Because pressure from the "race to fish" remains under license limitation, economic inefficiency induced by license limitation has the potential to erode any increases in economic rent (profits). Attempts to bind up a single input induce expansion of unregulated inputs, so these components may in turn require regulation. This regulatory complexity would raise the costs of management. Alternatively, other regulations might be necessary to limit catches or fishing power. Finally, the cap on expansions in vessel size to brake productive capabilities appears to be well founded. (D. Squires, [619] 546-7113)

Workshop Held on Airborne Remote Sensing

John Hunter (Coastal Fisheries Resources Division Chief [SWFSC, NMFS]) and James Churnside (Office of Oceanic and Atmospheric Research [OAR]) co-chaired a workshop on Airborne Fishery Technology, which was held in Boulder, Colorado, from March 22-24. The workshop was jointly sponsored by NMFS and OAR. Scientists participating were from NOAA, other U.S and Canadian agencies, and academia, and importantly, the seminar was also attended by industrial technology representatives. Existing technology for airborne sensing of fish, including light detection and ranging (LIDAR) and various passive systems, were reviewed and discussed as were the statistical properties of airborne biomass surveys, characteristics of fish school targets from the air, airborne characterization of fish habitat in the open ocean, and the status of present airborne fish censuses. The general findings of the meeting are described below.

Attendees agreed that the focus of airborne survey instrument development for fisheries should be on biomass estimation because this has the greatest management and scientific payoff. Accurate airborne biomass surveys of some epipelagic fishes are feasible using a combination of existing LIDAR and passive imaging technologies. LIDAR systems have the capability of increasing fish detection depth based on vision by a factor of 5-10, while passive imaging and image processing systems would not be expected to more than double the maximum school detection depth based on vision alone. However, passive imaging systems may provide information for species identification not available from LIDAR.

Direct airborne estimates of biomass are probably most practical for stocks of small epipelagic fishes (sardines, menhadens, anchovies, mackerels, herrings, and capelins). The optimal strategy for developing an open ocean airborne survey instrument for estimating the biomass of fish stocks shall consist of a combination of modeling and airborne field testing with target validation. The key initial measurements that need to be taken in order of priority are (1) determine the consistency that school thickness can be measured within a swath and/or develop a within-swath index of fish packing density, and (2) develop species identification criteria and estimate the depth-specific attenuation coefficient for species identification.

In smaller pelagic fishes, where counts of individuals are impractical, biomass can be estimated by estimating biomass of fish occurring within the narrow transect lines, regardless of how the lines traverse a school. This means that detailed reconnaissance and measurement of the volume and fish-packing density of entire schools is not needed. Due to the patchiness of fish schools and their sizes, increasing the swath width from less than 1 meter to tens of meters (or in some cases, hundreds of meters) has only a minor effect on school detection rates. This means that biomass survey instruments for small pelagic fishes need only sense a path less than a meter wide.

The usefulness of airborne biomass surveys will depend upon the consistency that school thickness and/or school packing density can be measured, the depth-specific attenuation coefficient for species identification, the depth-specific attenuation coefficient for fish detection, and upon the vertical distribution of the species. If initial work indicates that acceptable levels of precision for biomass estimation are unlikely, the focus should change from biomass estimation to improving the precision of aerial indices of abundance. Fishery managers have little use for a very imprecise biomass estimate while indices of abundance are valuable stock assessment tools when used to monitor trends in abundance over years.

Substantial opportunities exist to improve the precision of indices of abundance based on visual inventories or conventional aerial photography. The optimal research strategy for improving surface indices of abundance is not the same as biomass estimation although any advance for one objective would most certainly benefit the other. The first priority to improve visual or photographic surface indices of abundance would focus on improving near-surface detection, identification, and resolution of schools. Application of new passive imaging technology or LIDAR can increase precision by increasing detectability of schools, increasing the range of sea conditions under which observations can be made, increasing depth of school detection, eliminating dependency of night observations on moon phase and ambient bioluminescence, and providing criteria (in addition to the horizontal area of a school) that can be used as indices of school biomass.

A precise index of local abundance seems to be the most practical goal for tunas because, due to their great vertical depth range, it is doubtful that a major fraction of the stock would be consistently within the depth range of the instrument where species-specific biomass estimates could be made. In addition, due to the vast size of the habitat occupied by most tuna stocks, local or regional estimates of relative abundance, rather than stock biomass, seems to be a more practical goal. For salmon, open-sea biomass estimations are not as important as for the other fishes and are not likely to be successful because different species of salmon occur together and are very similar in appearance—making species identification from the air impractical. In some cases it may be practical to count individual fish rather than estimate biomass of schools or portions of schools. This appears to be the case for large tuna, particularly giant bluefin along the Atlantic coast and for salmon in the open sea. Scanning systems with broad swath width may be the optimal survey instrument in such applications.

Studies of ocean distribution of salmon and tuna in relation to ocean features may be the most useful application of airborne remote sensing for these large epipelagic fishes. Migratory routes, timing of migration, and availability to surface fisheries are critical management issues for both salmon and tuna. In addition, the carrying capacity of the Subarctic Pacific is an important Pacific salmon issue. Airborne remote sensing of fish and habitat offers some substantial opportunities for scientific advancement in these areas. (J. Hunter, [619] 546-7127)

Research Conducted on Methods Used to Determine Economic Value of Sportfishing in Southern California

Industry Economist Cynthia Thomson has completed a paper with Catherine Kling, Iowa State University, titled "The implications of model specification for welfare estimation in

nested logit models." In the paper, Thomson and Kling use data gathered in the Southern California Sportfish Economic Survey to estimate the effects of travel costs, catch rates, and other variables on angler decisions about fishing mode (that is, beach, pier, party/charter boat, private boat) and fishing site. The resulting parameter estimates were then used to derive estimates of economic value for each mode and site.

Thomson and Kling evaluated how sensitive the estimates of economic value are to alternative model specifications and estimation techniques. In particular, angler decisions regarding mode and area were modeled using (1) a multinomial logit model and (2) a nested logit model estimated by (a) a sequential estimation technique and (b) full information maximum likelihood (FIML). Multinomial logit requires that the respective probabilities of choosing each mode/site alternative be independent of other choices in that mode/site. Nested logit tempers this restrictive assumption by allowing some correlation among alternatives. For instance, the choice of a beach site may be correlated with other beach sites but not with sites associated with other fishing modes. In this case, the choice of fishing mode (beach) and the choice of sites within each mode would comprise different "nesting levels." FIML is statistically preferable to sequential estimation for estimating nested logit models since the sequential technique yields asymptotically inefficient parameter estimates and inconsistent standard error estimates.

As shown in this study, the disadvantages of the sequential estimator relative to FIML are not limited to its statistically undesirable properties. Sequential estimation constrains the analyst's choice of variables due to the difficulty of including variables whose values do not vary across levels of the nest. For those variables that do vary across nesting levels, sequential estimation is less amenable to accommodating cross-level differences in coefficient values. Moreover, the simple bootstrap technique used in this study to estimate standard errors for the FIML measures of economic value cannot be applied to sequential measures.

Results indicate that alternative model specifications and estimation techniques yield significantly different estimates of economic value. One result with potentially significant policy implications is the consistently larger measures of economic value obtained with sequential estimation relative to FIML. This result is particularly noteworthy given the disadvantages of sequential estimation cited above and its common use in the recreational literature.

As a separate exercise, FIML was used to estimate four different versions of the nested logit model, each corresponding to a different nesting structure but similar in all other aspects of model specification. Using the likelihood dominance criterion as the basis for model selection, the nesting structure found to be dominant (that is, most consistent with the data) was one that is not commonly used in recreation applications. This suggests the need for analysts to take a broader view in choosing nesting structure.

The paper has been submitted to an economics journal. (C. Thomson, [619] 546-7116)

MARINE MAMMAL DIVISION

La Jolla, California

Second Dolphin-Safe Research Workshop Held March 14-17, 1994

The second Dolphin-Safe Research Workshop was held at the Southwest Fisheries Science Center March 14-17, 1994, to evaluate and prioritize research on methods of detecting and capturing large yellowfin tuna in the eastern tropical Pacific (ETP) without intentionally encircling dolphins. The workshop included three groups, each contributing a unique knowledge base and perspective to the workshop. The first group included technical experts familiar with the mechanics and physics of one or more of the three detection methods (optic, acoustic, and radar/synthetic aperture radar [SAR]) discussed during the workshop. The second group included three types of ETP purse seine fishery experts, fleet owners (as overseers of the economics of the fishery), fleet managers (as more closely connected to day-to-day fleet operations), and vessel operators (as practicing experts in field operations of the fishery). The third group included government scientists familiar with the oceanography and ecology of the ETP ecosystemand the "tuna-dolphin problem." Fishery experts included members from both U.S. and Mexican fishing communities. Government scientists included representatives from the U.S. National Marine Fisheries Service (NMFS), Mexico's Programa Nacional para el Aprovechamiento del Atun y Proteccion de los Delfines (PNNAADD), and the Inter-American

Tropical Tuna Commission. Participation by fishing industry representatives from Mexico was important because the Mexican fleet is by far the largest component of the current ETP tuna purse seine fleet. Participation by government scientists from all three agencies was important because they are all actively involved in developing solutions to the tuna-dolphin problem.

The primary objective of the workshop was to discuss, evaluate, and prioritize research on alternative methods of detecting and capturing the large yellowfin tuna that usually associate with dolphins in the ETP. Participants were instructed to limit discussions to the large yellowfin tuna, excluding the smaller sized fish which tend to be associated with school or log fishing. In addition, they were limited in their discussions to the geographical area of the ETP, which excluded other oceans that might have different oceanographic characteristics. And finally, they were limited to detection methods which did not require dolphin sightings as cues. The only deviation from these limits was in regard to the discussion of utilizing pair trawls as an alternative fishing method in the ETP.

This narrow focus on the objective was chosen because, even though the large yellowfin tuna that associate with dolphins in the ETP are currently an abundant, valuable, and demonstratively sustainable resource, it has been suggested that, for a number of reasons, this resource may be lost due to commercial overexploitation if dolphin fishing is eliminated. This is based on current catch statistics which, when incorporated into population dynamics models, show that because more juvenile nonreproductive fish are being caught using methods such as school and log fishing rather than dolphin fishing, the future estimates of abundance for this resource will likely be reduced dramatically. The specific topics chosen for discussion and evaluation at the workshop were the three most promising detection methods available currently or in the near term (Day 1—acoustic; Day 2—optics; Day 3, morning session—radar/SAR), and the most economically promising new capture method proposed to date (Day 3, afternoon session—pair trawling).

Acoustic Detection Methods. This session opened with a brief description of the currently and potentially available acoustic detection methods. Specific problems associated with these methods were also described. In particular, the unusually shallow thermocline in the ETP likely precludes using simple acoustic methods because sound signals would be deflected downward and out of the layer instead of laterally to and from any sound source within the thermocline.

Workshop participants agreed that two fundamental research projects must be completed prior to any development or testing of an acoustic detection system. First, mathematical modeling of detection signal propagation through the oceanic environment of the ETP tuna purse seine fishing grounds will be required to determine whether these detection methods are feasible. Second, characterization of the target signature of individual or schooled large yellowfin tuna will be extremely important to determine those regions of detection signal range which actually pertain to this specific fish. The technical experts noted that these two projects could be accomplished using mathematical models.

After considerable discussion, the technical experts concluded that active acoustic methods most worth pursuing were dipping sonar (helicopter mounted), deeply towed sonar, and hull-mounted bottom bounce or convergence-zone sonar. Passive systems were not considered to be viable detection devices because passive systems are currently not feasible for long-distance detection. Although passive systems might be useful for close-range detection, there was a consensus that these systems would not provide any extra detection capabilities because the fishermen believe that the larger-sized fish found in large schools are associated with dolphins and that the systems currently on the market already provide adequate detection of tuna in association with dolphins.

The fishing experts suggested a number of characteristics that would be desirable for any acoustic detection system:

(1) Vessels with helicopters could utilize a system that
   (A) detects fish within 5-20 miles,
   (B) identifies at least 5-10 tons/set, 2-3 times per day, and
   (C) works at depths less than 300 feet.

(2) Vessels without helicopters need systems that
   (A) identify fish depth and location relative to the vessel,
   (B) estimate tonnage,
   (C) estimate species or at least the size of individuals,
   (D) work at speeds in the range of 10-15 knots, and
   (E) have an automatic target recognition with alert.

Optical Detection Methods. The primary physical constraint dictating propagation of light through water is the attenuation coefficient, k, as in the simple equation for light intensity as a function of distance from the light source in water ($I_R = I_o e^{-kR}$). In turbid water, k is larger; in clear water, k is smaller. In clear tropical water such as in the ETP, k is about 0.05, which in practical terms means that about 2/3 (67 percent) of any available light is lost (absorbed) every 20 meters (60 feet). Although much greater than in turbid (for example, coastal) systems, in the ETP the light available at 60 meters (3 attenuation lengths) for a light source will be less than 4 percent of that available at the source. There was a general consensus that optical detection systems will be better deployed on a relatively rapidly moving airborne platform than on a relatively slow-moving fishing vessel.

As an airborne platform, a surveyor using an optical system would be capable of surveying a much greater volume of water each time than would a surveyor on board the ship. For the ETP fishery, this platform would most likely be the vessel's helicopter. The possibility of using a drone was also discussed. An aerial platform could fly a search pattern around and in front of the fishing vessel. Basically, an optical detection system would enhance the standard visual search of surface conditions by providing a narrower but subsurface search swath.

Fishermen noted a number of constraints on the use of a practical optical system in the ETP. A system deployed in a helicopter would be required to work while flying at an altitude of between 1,000-1,500 feet during a period when no surface cues were visible. Ideally, fishermen would prefer a system that could both detect and identify fish down to about 300 feet with a swath size of about 1/2 mile x 1/2 mile. More realistically, in terms of current or developing technology, the fishermen required that such a system be a "user friendly" optic method that would enhance their sighting efficiency over current visual, sonar, and radar methods. In their view, it would not be economical if the system required a technician to work it.

Detection Methods Using Radar/SAR Systems. Radar is an active microwave system that emits electromagnetic radiation in the form of a radio-frequency energy beam. Objects that interrupt this beam reflect part of the energy back to a receiver, where the returning energy signal is analyzed to determine whether it corresponds to a desired target. The primary limitation in using radar for fish detection is that the signal does not penetrate or propagate through water. Only aerial objects or water-surface disturbances can be visualized with this method. A potential advantage to radar systems is their ability to work day or night, being unaffected by the presence of sunlight.

Related technologies include thermal infrared systems, passive microwave systems, and SAR. Thermal infrared systems passively receive shorter wavelength radiation, later recording emittance from a very thin surface, with little depth penetration. The signal can be obscured by atmospheric absorption by various particles such as dust, water, and gases (O_2, O_3, CO_2). Passive microwave systems can operate day or night in almost all weather conditions and are less attenuated than infrared systems by clouds and fog. These systems operate in the same electromagnetic spectrum range as radar but do not generate any radiation.

SAR systems are active detection systems carried by aircraft, including satellites. The system coherently processes signal returns over a period of time to produce an image of a surface similar to a photograph. In general, SAR is used to visualize large areas (to several hundred square miles). A SAR system would not visualize single birds but could probably identify disturbances caused by schooling fish or oceanographic conditions favorable for fishing. The system will work equally well day or night, and it also works well when clouds are present. A major disadvantage of the system is that, similar to a photograph, the image is produced from a relatively short time exposure (a few seconds to a few minutes) so that if a school is not near the surface during that imaging time, it will be missed.

For the ETP, the technical experts identified three relevant scales for detection which were based on the platform carrying the radar. The tuna vessel itself would be the appropriate platform for the detection of fish at distances less than about 20 miles. Aircraft would be appropriate for scales in the 20- to 100-mile range. Satellites would be required for detection distances greater than about 100 miles. Because radar does not penetrate the water's surface, participants agreed that it would not provide useful information at very close ranges. However, further discussions indicated that existing radar systems which are used by the fishermen to detect flocks of birds (a cue for schools of fish) could be improved.

Pair Trawls as an Alternative Capture Method. Pair trawling is a capture method that involves two vessels, each hauling one side of a very large, but otherwise traditional, mid-water trawl. The advantages to pair trawling are the large size of the net that can be accommodated and the relatively high towing speed that can be attained. This potentially dolphin-safe technology is capture-based rather than detection-based but was considered during the workshop for three compelling reasons. First, pair trawling is the most economically promising non-purse seine capture method that has been proposed to date. The gear has good potential for high productivity, and it could probably be used at night. In addition, it is relatively inexpensive to construct. Second, pair trawling has proven to be successful for capturing tuna in other oceans. Third, the method has promise as a "low-bycatch" alternative to setting purse seines around floating objects.

Pair trawlers are less likely to capture dolphins because dolphins swim quite close to the surface when moving rapidly, as when chased by speed boats. By towing the trawl beneath the fast-swimming dolphins and in the opposite direction, it is likely that some or all the tuna swimming below can be collected in the net without simultaneously entrapping dolphins. It is also likely that at least the bycatch of surface-oriented fish associated with floating objects (generally the smaller individuals) can be eliminated by replacing purse seining with pair trawling because the deeper path of the trawl will selectively capture only the larger fish generally found relatively deep beneath floating objects. This is important because bycatch associated with purse seine fishing on floating objects is extensive.

Although this appears to be a promising method of fishing for large yellowfin tuna without encircling dolphins, several potential problems and unanswered questions arose during the workshop discussions. Most of the questions were related to the behavior of tuna and dolphins in the presence of such gear and how this type of gear could be transferred to the purse seine vessel. Most of these questions can only be answered by conducting some trial sets. Some potentially serious engineering problems could be addressed at least partially prior to field trials. In particular, trawling could not be conducted with mismatched engines (that is, between boats of very different sizes), and the configuration of tuna seiner engines, gears, and propellers, which are optimized for continuous high-speed travel, may require alteration for the slower heavy-load capacity required by trawling.

Workshop Conclusions and Recommendations. The workshop produced a comprehensive picture of the possibilities for locating and capturing large yellowfin tuna in the ETP which are not associated with dolphins. There are a number of basic uncertainties associated with developing alternative means of locating yellowfin tuna, and the fundamental research questions that must be answered to address those uncertainties became quite clear. Essentially, the same conclusions were reached about immediate research needs for all three of the detection technologies discussed (acoustics, optics, and radar). In all three cases it became apparent that two relatively straightforward modeling projects will be required prior to development of any detection system specific to locating large yellowfin tuna in the ETP. First, signal propagation in the eastern tropical Pacific will have to be modeled mathematically to determine what forms of detection systems will be appropriate for this specific area. Fortunately, the models needed for such preliminary investigations are readily available for all three detection methods. Second, mathematical modeling or direct measurements of the target signatures of large yellowfin tuna will be required to determine the extent to which these fish singly or in groups will be detectable by any of the detection modes.

Provided that the acoustic models show promise, the second stage of this research process must involve planning and deployment of an acoustic survey of the distribution and abundance of large yellowfin tuna in the ETP. There was consensus among the participants that acoustic detection is the only detection method appropriate for a wide-area, subsurface survey in the ETP. It will be important to determine whether there are "fishable" quantities of yellowfin tuna that are not associated with dolphins.

A final report of this research planning workshop to prioritize dolphin safe research should be available by the end of August 1994. (E. Edwards, [619] 546-7099)

Potential Biological Removal Workshop Held June 27-29, 1994

The 1994 amendments to the Marine Mammal Protection Act (MMPA) require NMFS and the U.S.

Fish and Wildlife Service (USFWS) to complete stock assessment reports for all marine mammal species within U.S. waters by August 1, 1994. These stock assessments must include information on how stocks were defined, a calculation of Potential Biological Removals (PBRs), and an assessment of whether incidental fishery takes are "insignificant and approaching zero mortality and [zero] serious injury rate." Because the amendments provided only limited guidance and because there is a clear need to establish quantitative criteria that may be consistently applied to marine mammal stocks between regions for developing the stock assessment reports, NMFS convened a workshop with the USFWS to review and come to an agreement on these issues. The workshop was held at the Scripps Institution of Oceanography, La Jolla, California, June 27-29, 1994.

Jay Barlow, leader of the Coastal Marine Mammal Program, convened the workshop and directed the participants to keep in mind the primary goal of the MMPA, which is to maintain the health and stability of marine ecosystems. Also within the Act are three explicit goals, to maintain stocks at Optimum Sustainable Population (OSP) levels and as functioning elements of their ecosystems, to restore depleted stocks to OSP levels, and to reduce incidental mortality to "insignificant levels approaching a zero mortality and [zero] serious injury rate." The legislative record of this Act frequently refers to another implicit goal which is to minimize interference with commercial fishing enterprises while meeting the other goals. In order to measure the quantitative performance of any proposal to meet these goals, it is necessary to quantify what is meant by them. In this regard, the workshop participants agreed on the following interpretations:

Goal 1: Maintain OSP and Ecosystem Function—The workshop participants interpreted the goals of maintaining stocks within OSP levels as functioning elements of their ecosystems as being met if, following removal of the estimated PBR each year, stocks equilibrate within OSP 95 percent of the time, assuming reasonable levels of imprecision in estimating population size, take levels, and population growth rates. Scientific review groups have been established as directed under the revised MMPA to review the scientific validity of these estimates and their associated level of imprecision.

Goal 2: Restore Depleted Stocks to OSP—For stocks that are endangered, threatened, or depleted (or for stocks of unknown status) which are not known to be increasing in the presence of human-induced mortality, an additional level of protection should be applied to ensure recovery to OSP. The workshop participants believed that this additional protection should allow stocks to equilibrate within OSP levels 95 percent of the time while taking into account probable ranges of imprecision and error (bias) in measuring population size, take levels, and population growth rates. If a stock is endangered, PBR levels should not exceed "insignificant levels." These levels are not defined in the MMPA, and the workshop participants agreed that one way of defining this level using population growth models would be to state that in no case should allowable take levels delay recovery by more than 10 percent of the estimated recovery time in the absence of any incidental take.

Goal 3: Zero Mortality Rate Goal—The workshop participants interpreted this goal to be met by reducing incidental mortality from commercial fishing operations to levels significantly below allowable PBR levels so that the incidental mortality has a negligible effect on the status of the affected stock, and for stocks listed as endangered or threatened under the Endangered Species Act, to levels such that the estimated time required for those stocks to recover to OSP is not significantly increased.

Goal 4: Minimize Unnecessary Interference with Commercial Fisheries—The workshop participants interpreted this goal to mean that limits on allowable removals (that is, incidental mortality and serious injury) should not be unnecessarily conservative or restrictive of commercial fishing operations, while remaining consistent with the other goals of the MMPA.

PBR Criteria. The 1994 amendments to the MMPA state that, as part of the stock assessment reports, NMFS must develop estimates of Potential Biological Removals (PBRs) for each marine mammal stock in U.S. waters. The term PBR means "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBRs are calculated as the product of three elements: (1) the minimum population estimate (N_{MIN}); half the maximum net productivity rate (0.5 R_{MAX}); and a recovery factor (F_R). It was the workshop participants' principal objective to identify criteria for defining input values for these elements that would

serve as a nationwide standard for calculating PBRs.

N_{MIN} is defined in the amendments as an estimate of the number of animals in a stock that (A) "is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information, and (B) provides reasonable assurance that the stock is equal to or greater than the estimate."

One-half the R_{MAX} is defined as "one-half the maximum theoretical or estimated 'net productivity rate' of the stock at a small population size," where the term 'net productivity rate' means "the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to natural mortality." The Act does not specifically define F_R; instead it is given as a factor with a range of between 1.0 and 0.1.

The workshop participants concluded that the three PBR parameters must be evaluated together, rather than independently, in the context of meeting the goals of the MMPA. For example, if recovery factors selected are very conservative, the definition of N_{MIN} can be less so and still provide an equivalent estimate of PBR. It was the consensus of the workshop participants that values for N_{MIN} might be estimated that would result in stocks reaching equilibrium within their range of OSP, that default or empirically based estimates for one-half R_{MAX} could be identified, and that F_R should serve to weight the PBRs so as to take into account uncertainty in those estimates. In this sense F_R was considered a "safety factor" that would allow the taking of individuals from stocks below OSP while continuing to promote their recovery and that would provide a safety margin to account for unknown bias in stock status information (for example, estimation of abundance, productivity, mortality) and for stocks of unknown status or trends.

Some of the participants commented that distinct advantages of the PBR approach include the following: (1) It is not driven by population models, (2) It incorporates conservative factors, (3) It provides an incentive to improve information on stock size (for example, to lower coefficients of variation [CV]), and (4) It focuses on achievable goals. They noted, however, that once specific values for input parameters for the three elements are identified, their performance should be evaluated with the use of simulation models.

The results of three separate simulations were presented during the workshop. Fishery Research Biologist Barbara Taylor compared two management strategies, one which uses the mean (or "best") estimate of abundance and one which uses a minimum estimate of abundance using simulations to emulate the possible outcomes of management strategies on different types of populations. To test the management schemes, she followed the structure used by the International Whaling Commission in testing the Revised Management Plan. These simulations are used to project the population sizes through time and can be subjected to different types of effort and the results examined in light of management goals (see Southwest Fisheries Science Center [SWFSC] Technical Memorandum No. 188). National Research Council Fellow Paul Wade proposed a two-step strategy for selecting values for N_{MIN} and F_R and used computer simulations similar to those presented by Taylor to evaluate the robustness of his model (see SWFSC Administrative Report LJ-94-19). James Lerczak, Rodd Hobbs, and Doug DeMaster from the National Marine Mammal Laboratory, working with Taylor, also used these same types of computer simulations to determine the response of marine mammal population growth to annual PBRs (PBR Workshop Document No. 4).

Minimum Population Estimate (N_{MIN}). N_{MIN} is defined in the amendments as an estimate of the number of animals in a stock that (A) "is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information, and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate."

For N_{MIN}, members of the workshop adopted Wade's proposal to use the 20th percentile of a log-normal distribution based on an estimate of the number of animals in a stock (which is equivalent to the lower 60th percentile of a confidence limit of an abundance estimate), calculated as

$$N_{MIN} = N/exp(z\ (ln(1+CV(N)^2))^{1/2}), \qquad (1)$$

where N is the abundance estimate, $CV(N)$ is the coefficient of variation of the abundance estimate, and z=0.842. In cases where a direct count was available, such as for many pinniped stocks, this direct count (corrected when possible to include a minimum estimate of the animals not counted)

could alternatively be used as the estimate of N_{MIN}. Such a corrected count can be used as the estimate for N_{MIN} provided that a variance for that estimate is available, in which case N_{MIN} is the lower 60th percentile of the appropriate statistical confidence interval.

Workshop participants emphasized the need for frequently updating abundance estimates, both as a means for ensuring current estimates of PBR and as a method for detecting failures of the PBR approach. It was agreed that calculated PBR values should be decreased by 20 percent per year when minimum population estimates are more than 5 years old. If abundance estimates are not updated, PBRs would therefore decrease to zero 10 years after the last abundance estimate.

The original NMFS MMPA proposal to Congress suggested using a lower 95 percent confidence limit (the 2.5th percentile). Fishery Research Biologist Barbara Taylor presented simulation studies that indicated that the 2.5th percentile, in combination with an F_R of 0.5, was lower than necessary to allow stocks to recover to or remain at OSP, even in the presence of substantial, but plausible, bias in the abundance and mortality estimates or in the default value used for one-half R_{MAX}.

Maximum Rate of Increase (R_{MAX}). The workshop participants proposed that default values be used for R_{MAX} in the absence of stock-specific measured values. These default values should be 0.12 for pinnipeds and sea otters and 0.04 for cetaceans and manatees. The default value for pinnipeds and otters was selected by conservatively choosing the lower end of the range of measured maximum population growth rates for these taxa: 12 to 18 percent per year. The default value for cetaceans is based on theoretical calculations that show that dolphin populations cannot grow at rates much greater than 4 percent, given the constraints of their reproductive life history. Whales and manatees were included with dolphins based on similarities in their life history characteristics. These default values are believed to be within a reasonable range of values for these species, but this crude classification is not meant to suggest that the growth potential of all species and stocks within these groups is equal. Much lower values (as small as half the default values) should not be considered unreasonable. Management guidelines should therefore be sufficiently robust that MMPA goals are still achieved when actual values are lower than the defaults.

Recovery Factor (F_R). The Act does not specifically define F_R; instead it is given as a factor with a range between 1.0 and 0.1. The workshop participants agreed that the F_R should be considered a safety factor and, therefore, the default values for F_R for depleted or threatened stocks or for stocks of unknown status would be 0.50 for pinnipeds and 0.65 for cetaceans. They also agreed that stocks known to be at OSP or to be increasing in the presence of takes greater than the PBR calculated under the default value could have higher values up to and including 1.0.

Zero Mortality Rate Goal. The 1994 MMPA amendments reaffirm the goal set forth in the Act when it was enacted in 1972 that the take of marine mammals in commercial fisheries be reduced to insignificant levels approaching zero mortality and [zero] serious injury rate. The amendments require that stock assessment reports describe fisheries that interact with (that is, kill or seriously injure) marine mammals. These descriptions must contain "an analysis stating whether such level is significant and is approaching a zero mortality and [zero] serious injury rate." The Amendments also state that all commercial fisheries must reduce incidental mortality and serious injury of marine mammals to insignificant levels approaching zero mortality rates within 7 years of enactment of the 1994 amendments. This will be referred to as the "zero mortality rate goal."

Definition of "stock." The participants agreed that, at the species level, taxonomy in the stock assessment reports should be consistent with the current classifications (see, for example, D. E. Wilson's and D. M. Reeder's 1993 reference guide *Mammal Species of the World: A Taxonomic and Geographic Reference*, which is available through the Smithsonian Institution Press, Washington and London). Below this level, the population "stock" is the fundamental unit of legally mandated conservation efforts. In practice, its determination is often a problematic, but nevertheless essential, exercise. The MMPA provided both the biological and ecological guidance for making such determinations. The biological guidance is in the definition of population stock: a group of animals in common spatial arrangement that interbreeds. The ecological

guidance is addressed in the requirement that a stock be maintained as a functioning element of the ecosystem. The clear intent of the MMPA is to restore and maintain stocks within their OSP. Therefore, workshop participants specified that a risk-aversion strategy of defining the stocks should be used to be consistent with these goals.

Future Research Needs. Throughout their discussions, the workshop participants identified numerous opportunities for continuing or additional research that would advance and assess the performance of the PBR scheme. In this regard, they identified the following research areas:

(1) Develop a realistic basis for the robustness trials: The robustness trials used in three of the background documents (Taylor-PBR/3, Lerczak et al.-PBR/4, and Wade-PBR/5) are hypothetical scenarios and are applied individually. Examples based on case histories from each region could provide a more realistic set of scenarios and indicate some multiple interactions. An example is a highly aggregated stock in which both the abundance estimate and the kill estimate could be significantly affected by a few large samples.

(2) Ancillary PBR information: Since all possible data should be incorporated into the PBR estimations, there is a need to develop methods for calculating a PBR that include data gathered from sources other than that used in the most recent abundance estimate. Factors to consider are history of abundance and catch estimates similar to the International Whaling Commission approach and information on immigration and emigration from tagging or tracking experiments.

(3) Review pinniped R_{MAX} information: A review is needed of the information available on R_{MAX} for pinnipeds, similar to the work of Reilly and Barlow (1986) for delphinids and Best (1993) for baleen whales.

(4) PBR input parameters: There is a need to develop an approach for using ancillary information (parameter values and estimates of their precision) that would allow an adjustment of the recovery factor or R_{MAX} for specific stocks. The actual adjustment would be made on a stock-by-stock basis. This exercise would provide a shopping list of potential issues and rank them according to importance.

(5) Alternative population models: The performance of the PBR proposal should be tested using a variety of different population models (for example, models that account for age and sex structure, variation in recruitment, variation in k (carrying capacity), spatial distribution and movement, or which allow an occasional catastrophic decline in abundance unrelated to fishery mortality). This does not fall under the intent of the present system but could have implications for long-term management.

(6) Identification of beaked whale stocks: There is a need to develop methods to identify beaked whales (by species level) which may be killed incidental to fishing operations. These methods must be easily performed on the deck of a small fishing vessel or on other platforms at sea. Some possibilities include collecting tissue, blood, tooth or jaw samples, or skulls from incidentally caught specimens.

(7) Mixed species stocks: There is a need to develop a method for calculating PBRs for mixed species groups (for example, *Mesoplodon* sp.) when kill and/or census data cannot be prorated to species and several species are known to be present.

(8) F_R CV value assessment: A method is needed to modify F_R values to explicitly account for the CV of the kill estimate. The idea is to allow a relaxation of F_R if kill estimates are considered to be precise.

(9) F_R tuning procedure: There is a need to develop a method for tuning the F_R to the level of uncertainty in the PBR elements for a specific stock.

(10) Survey correction factors: Species-specific correction factors need to be developed to correct sighting survey estimates for species with very long dive times and cryptic surfacing behavior (for example, beaked whales).

(11) Stock subdivisions: There is a need to evaluate the effects on PBR calculations and stock conservation of various levels of subdivision for stocks with broad geographical ranges, but for which there is no information on stock structure.

(12) Stock identification: Additional research is needed to progressively refine knowledge of population structure. Research should include gathering data and analyzing and interpreting the data. Interpretation of such data

will require modeling to address the power of assessing population structure as well.

(13) PBR bias and precision: There needs to be a general consideration of the effect of bias and the relationship between bias and precision in abundance and kill estimates in relation to the PBR calculations.

Criteria for Defining PBR Elements. Through its deliberations the workshop participants developed these draft criteria for defining the elements for calculating PBRs (that is, minimum population size, one-half the maximum rate of increase, and the recovery factor), criteria for stock identification, and criteria for evaluating progress toward the "zero mortality rate goal." A draft report of the conclusions from the workshop as well as the draft stock assessment reports are available for review and public comment. A notice of their availability was published in the Federal Register on August 9, 1994, and may be obtained from the NMFS Office of Protected Resources in Silver Spring, Maryland; the Southwest Region in Long Beach, California; or the Southwest Fisheries Science Center in La Jolla, California. The final workshop report and stock assessment reports will be completed by February 1995. (J. Barlow, [619] 546-7178)

HONOLULU LABORATORY

Honolulu, Hawaii

Marine Fisheries Review Special Issue Published

The special issue of *Marine Fisheries Review* edited by former Honolulu Laboratory Director George Boehlert has been published. This issue, "The fisheries of Hawaii and U.S.-associated Pacific Islands," is the first published source of fisheries information for Hawaii and the U.S.-associated Pacific Islands available to scientists and the general public. Its scope is limited to domestic island-based, rather than distant-water, fisheries, thereby excluding tuna purse seine and albacore fisheries and island-based foreign fleets such as Guam and American Samoa. Each article includes information on the biology of the species involved, a synopsis of the fishery, current research and research needs, issues associated with management and regulation of the fishery, and future prospects. These articles, with abstracts, are cited in the Publications section of this report. (M. Laurs, [808] 943-1211)

HAWAII REGIONAL COASTWATCH NODE

Sea Surface Temperature Images Received from NOAA Satellites

The Coastal Ocean Program's Hawaii Regional CoastWatch Node (HRCN), Honolulu Laboratory, is dedicated to providing government agencies and researchers with remotely sensed environmental data to assist in managing living marine resources and coastal ecosystems. To be effective, the data provided by CoastWatch must be both timely and at a level of processing that would provide usable and immediate information to users without sophisticated image processing systems.

Toward this end, the HRCN has installed a computer network, CoWaNet, to directly access satellite data from the National Weather Service in Honolulu, Hawaii. In particular, the HRCN now obtains four to six passes daily of Advanced Very High Resolution Radiometer (AVHRR) data from NOAA polar orbiting satellites.

Data from these passes are used to derive sea surface temperature (SST) images for different regions of the central Pacific. For example, Figure 1 is an SST image for a region enclosing the Hawaiian Islands. To facilitate analysis and use of these data, the CoastWatch Program provides a software package, Ccoast, which may be used to view these data on any PC with a Multisync or Super VGA monitor, 1 megabyte of expanded memory, 400 kilobytes of available system random access memory, and a mouse or other pointing device. Internet users with signed Memorandums of Agreement may acquire these data in real-time for display on their local DOS computers.

Investigators desiring CoastWatch AVHRR data should contact Craig Motell at the Honolulu Laboratory of the National Marine Fisheries Service using the Internet address "cmotell@pelagos.nmfs.hawaii.edu" (C. Motell, [808] 943-1279)

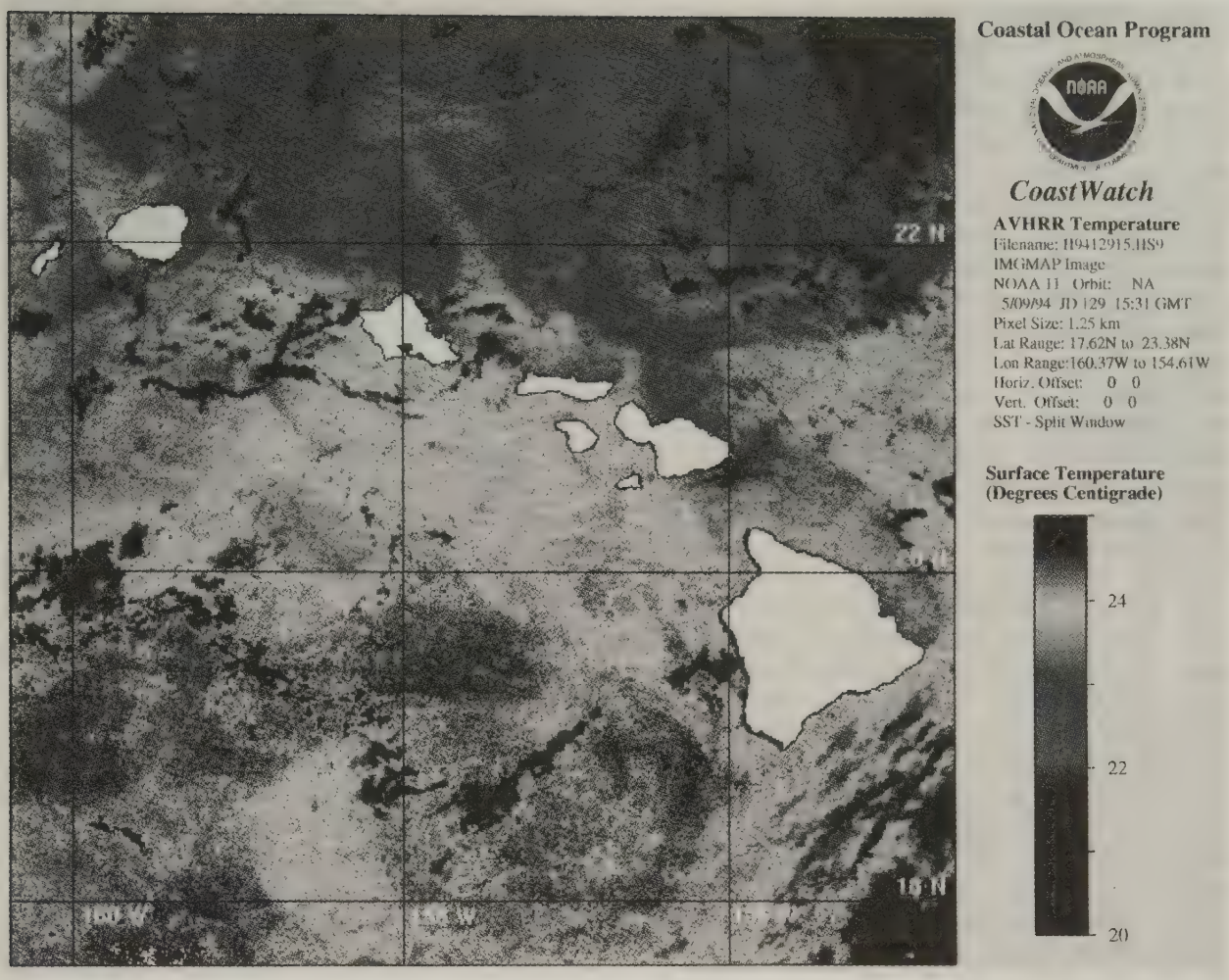

Figure 1. Advanced Very High Resolution Radiometer data received from NOAA polar orbiting satellites, showing a sea surface temperature image of a region enclosing the Hawaiian Islands.

PROTECTED SPECIES INVESTIGATION

Juvenile Hawaiian Monk Seals Relocated

Total abundance of the Hawaiian monk seal, *Monachus schauinslandi*, declined by approximately 50 percent between the late 1950s and the 1970s. Local populations at Kure Atoll and Midway Islands declined by 80-100 percent. Karl Kenyon, formerly with the U.S. Fish and Wildlife Service and one of the first biologists to do extensive work with monk seals, attributed losses at these two sites to human disturbance. He observed that the operation of a Coast Guard loran station at Kure Atoll caused adult females to abandon prime pupping areas for less suitable habitat, which resulted in reduced juvenile survival and, eventually, to reduced recruitment of mature females. The population declined in number and shifted to an unstable age distribution with a relative excess of older animals. The effects of disturbance related to military occupation and activities at Midway were not as well documented but were probably similar. In the mid to late 1950s, counts at Midway averaged over 50 animals; in 1968, an aerial survey detected a single seal. Arguably, the Midway population was driven extinct. The majority of seals currently at this site are immigrants from other populations or offspring of those immigrants.

A major objective of the Marine Mammal Research Program (MMRP) at the Honolulu Laboratory has been the recovery of these western

populations to predisturbance levels. Recovery appears to be under way at Kure, largely as a result of two important management actions. First, the Coast Guard modified its regulations and, together with biologists from NMFS, successfully reduced the disturbance of pupping sites and of females with pups. Second, two programs were initiated to increase recruitment of mature females. Weaned female pups were captured and held in a beach enclosure, where they learned to feed independently while they were protected from sharks and aggressive adult males. In addition, undersized weaned females from French Frigate Shoals were taken to Oahu for months of rehabilitation followed by relocation at Kure Atoll. The increase in juvenile survival, together with the infusion of immature females, has helped to stabilize the age distribution and has increased recruitment and reproduction at this site.

The Coast Guard loran station at Kure was closed in 1992 and, lacking regular transportation to and from this atoll, MMRP decided to shift its relocation program to Midway. Kenyon suggested that the Midway environment should be able to support a much larger seal population than was present in the 1950s, and the recovery of the Midway population has been a long-standing management goal. During 1992 and early 1993, 20 juvenile females were relocated to Midway Atoll. The results, however, were very discouraging: of those 20 seals, 18 either died or disappeared. The reasons for this failed effort have not been determined.

When these discouraging results became apparent, MMRP quickly altered its relocation site back to Kure Atoll, pending an investigation into the nature of the poor results at Midway. Since April 1993, 22 seals have been released at Kure. Eight of these seals have only recently been released, and the success of their relocation cannot yet be determined. The other 14 seals were released at Kure between April and September 1993, and as of February 1994, 10 of those seals were known to still be alive (2 have moved to Midway).

The better results for relocations to Kure Atoll suggest that the deaths and disappearance at Midway may be related to the Midway environment. For example, the danger of ciguatera poisoning is considered to be higher at Midway than at any other site in the Northwestern Hawaiian Islands, and some of the deaths at this site may have been due to such poisoning. However, scientists have no direct evidence of ciguatera poisoning, and this explanation is hypothetical at best. In general, the results at the two locations are difficult to compare because other rehabilitation factors were generally not the same. The seals taken to Midway were, on average, older, and past experiences suggest that older seals are more severely stressed by handling. In addition, nine of the seals were taken directly to Midway from French Frigate Shoals, without intermediate rehabilitation on Oahu. Five seals were released at Midway after rehabilitation similar to that received by seals taken to Kure, and of those five, only one has been sighted since 1992. Nevertheless, comparisons between release efforts at the two locations are difficult, and at this point, we have no clear explanation for the poor results at Midway. Further information related to the Midway environment may be forthcoming as the U.S. Navy completes its cleanup following the 1992 closure of the U.S. Naval Air Facility at this site.

Rehabilitation and relocation efforts will continue since they provide one of the most important methods by which management can intervene to enhance the survival of small or emaciated seals and to enhance the recovery of the western populations. The markedly different results at Midway and Kure Atolls suggest, however, that much remains to be learned about the process of rehabilitation and relocation. (T. Ragen, [808] 943-1280)

SWFSC Sea Turtle Scientist Hosted by Chelonian Institute in Nagoya, Japan

For 5 days during April, the Chelonian Institute founded by Itaru Uchida in Nagoya, Japan, sponsored Zoologist George Balazs as he conducted and planned cooperative research on marine turtles. The Institute, which opened in late 1992, is an integral part of the new $53 million Port of Nagoya Aquarium. The aquarium has been acclaimed as one of the most technologically advanced facilities of its kind in the world. Major innovative exhibits feature sea turtles, especially the loggerhead, *Caretta caretta*, that nests in significant numbers in the southern part of Japan.

During his visit, Balazs and staff veterinarians conducted comprehensive necropsies of loggerheads fatally captured in the former Japanese driftnet fishery in the North Pacific. Numerous valuable samples were collected and preserved for further analysis, including mtDNA, and skeletochronological, toxicological, and histological samples. Fatty acids were sampled and preserved to determine the pelagic food sources of these turtles. Many of these

samples are scheduled to be imported to Hawaii within the next few months, after the required Convention on International Trade in Endangered Species permits are issued by both Japan and the United States.

In addition to conducting turtle necropsies, Balazs spent time training his Japanese counterparts in current blood sampling techniques for live turtles and formulating broader plans for research relating to longline hooking of turtles. Blood samples were taken from many turtles on display at the aquarium whose nesting beach origins were positively known. The samples will eventually be analyzed for mtDNA to contribute knowledge of stock identification of loggerhead turtles on a global basis.

The short, but productive, visit laid a solid foundation for expanded cooperative research relating to current sea turtle issues and problems shared by the two countries. (G. Balazs, [808] 943-1240)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Western Pacific Fisheries Information Network Updated

The Western Pacific Fishery Information Network (WPACFIN) was established in 1981 to help monitor and manage fishery resources under U.S. jurisdiction in the central and western Pacific Ocean. This cooperative program is composed of local governmental and federal fisheries agencies in the Territories of American Samoa and Guam, the State of Hawaii, and the Commonwealth of the Northern Mariana Islands (CNMI). The program is coordinated by the central WPACFIN office located at the NMFS Honolulu Laboratory. The most important function of this office is to provide technical support to each of the local fisheries agencies for conducting all aspects of their fishery monitoring and managing responsibilities, from designing data collecting procedures and instruments to processing and analyzing the data to produce annual report modules for various Fishery Management Plan (FMP) Monitoring Teams. In turn, the local fisheries agencies collect and process the data required to properly monitor and manage their offshore and inshore marine resources and to actively participate in federal fishery management programs. To date, data systems have been designed, programmed, and implemented in most areas for processing data from offshore and inshore creel surveys, commercial landings, vessel inventories, import and export monitoring, market sampling for size frequency and biological studies, and tournament sampling. Data from these island systems are provided to the central WPACFIN office for archiving and use by qualified fisheries researchers.

In recent years, add-on funds from the WPACFIN initiative have made it possible for the central WPACFIN staff to provide much-needed technical support to island agencies. In February 1994 David Hamm, WPACFIN program manager, spent several days working with the data section staff of the CNMI Division of Fish and Wildlife (DFW) in an interactive management workshop designed to identify principal problems and needs of the data section. One important problem identified by the staff was a lack of understanding of the computer hardware and software required for processing their fishery data. In response, an intensive 8-day computer training workshop was held in March at the Department of Natural Resources (DNR) in Saipan by WPACFIN Senior Computer Programmer Michael Quach. Eight DNR and DFW staff and one visiting staff member from the Guam Department of Commerce received training on computer hardware maintenance and troubleshooting, MS/DOS, and dBASE IV. As resources permit, a second round of training will be scheduled to provide more specific and detailed training on field sampling techniques, data quality control and processing procedures, data management principles, and detailed use of the various WPACFIN-programmed applications packages installed at DFW. During the earlier workshop held by Hamm, DFW staff ranked this type of training as a high priority.

On-site technical support was also provided to staff at the American Samoa Department of Marine and Wildlife Resources (DMWR) when Hamm, accompanied by Bert Kikkawa, fishery biologist/analyst, and Henry Lum, computer programmer, spent the week of March 7 in Samoa. While Hamm worked with staff biologists, data technicians, and data managers on modifying the inshore creel survey system and producing the pelagics and bottomfish FMP annual report modules, Kikkawa worked with data management staff, discussing and resolving potential problems in the offshore survey data system. Lum worked on hardware problems and reprogramming and implementing software changes identified by Hamm and others. Kikkawa's work was part of a special data analysis

project (WPACFIN Island Data Assessment [WIDA]) recently undertaken by central WPACFIN on behalf of DMWR to help determine what changes are needed in the DMWR monitoring programs to obtain more useful fisheries data to support local and federal management requirements. Kikkawa recently completed a similar study for the Guam Division of Aquatic and Wildlife Resources (Honolulu Laboratory Administrative Report H-94-03). The WIDA reports will be the basis for designing and implementing future changes to data systems to improve monitoring and analysis of island fisheries to ultimately improve management of those fisheries. (D. Hamm, [808] 943-1214)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

Researchers Study Availability of Dolphin, *Coryphaena hippurus*

The dolphin (fish) catch off southern California was more than 8 percent of the total southern and Baja California CPFV catch in 1983, 1984, 1990, 1992, and 1993. The major portion of the catch is from northern Baja California. Record catches for southern and Baja California were recorded in 1990 and 1992.

Sexual maturity and lengths exceeding 100 centimeters commonly occur in the dolphin's first year. Individuals may live longer than 5 years, but in both commercial and sport fisheries, fewer than 5 percent of the fish taken are thought to be older than 2 years. About 85 percent of the dolphin taken by southern California Commercial Passenger Fishing Vessels (CPFV) anglers are less than 1 year old.

In the eastern Pacific, the largest concentrations of all dolphin life stages are in the tropical biogeographic zone, which extends from the equator north to the southern end of the Baja California Peninsula at 22.8° N latitude. Poleward migration into the northern subtropical biogeographic zone appears limited by factors associated with the 20 °C sea surface isotherm. Biogeographic zones would be expected to be plastic for wide-ranging nektonic species such as dolphin. Throughout the dolphin's range, peak catch is seasonal, suggesting annual migrations.

Since 1979, total annual catch of dolphin from southern and Baja California waters has varied 30 fold. Catch off southern California is episodic. Off Baja California, catch is more consistent with more than 1,000 dolphin caught each year. When the total catch exceeds 4,000 fish, 75-85 percent of the dolphin are taken north of Cabo San Quintin on 20- to 24-hour CPFV trips from San Diego and Oceanside, California. CPFVs are usually pursuing yellowfin tuna, *Thunnus albacares*; skipjack, *Euthynnus pelamis*; or yellowtail, *Seriola lalandi*, on these excursions. Dolphin are a desirable bycatch. If dolphin fishing is successful, the CPFV will not abandon this fishing to search for other species.

Dolphin are most frequently taken from beneath free-floating kelp mats, composed of tangled *Macrocystis* sp. stipes and blades (fronds). Locating the fish is highly dependent on the CPFV operator's ability to find floating kelp mats.

Many studies have focused on the basin-scale environmental events of seasonal to several years duration and their possible biological consequences. The best-known environmental events of this scale are the El Niño-Southern Oscillation (ENSO) and its global teleconnections. Because global anomalies associated with ENSO appear to be triggered by tropical Pacific events, it may be useful to compare tropical indicators of ENSO activity to physical conditions associated with the subtropical biogeographic zone and dolphin catch by southern California CPFV anglers.

Research by Oceanographer Jerrold Norton of the Pacific Fisheries Environmental Group and Steve Crooke of the California Department of Fish and Game compares variation in CPFV dolphin catch off southern and Baja California to several scales of variation in the physical environment and interprets these comparisons in terms of scenarios describing conditions that allow dolphin to enter the Southern California Bight. Results from this study will be reported in California Cooperative Oceanic Fisheries Investigation Reports, Volume 35.

The local importance of the 20 °C sea surface layer is verified by the present study. However, July-September mean surface temperatures within the Southern California Bight exceed 20 °C. From this it might be expected that dolphin would be more frequently found off southern California. The source and path of the warm water appears to be important. To import large numbers of dolphin, the continuity of the advective path from the region of

dolphin presence to the waters off southern California must be continuous and temporally uninterrupted by periods (areas) of cooler water. In the southern California eddy system, cool water (< 19 °C) during the dolphin fishing season may be the result of the more intense California Current on the large scale and increased coastal upwelling on regional and local scales. Both processes are intensified by increased eastern Pacific high-pressure system development and resulting southward winds along the coast.

The most productive CPFV dolphin fishing tactic is to cast live bait around floating objects, mainly kelp mats. Concentration and distribution of mats throughout the Bight may be important in making dolphin available to CPFV anglers. During warm water years (for example, 1990) free-floating kelp fronds may be more abundant due to grazing by kelp bed invertebrates as the thermo- and nutriclines are displaced deeper than the holdfasts and the overall kelp bed productivity is reduced. Aggregations of drifting fronds may be found in areas of hydrographic convergence, which may be important in attracting dolphin and associated fish.

Increased generation of eastern Pacific tropical cyclones which may be associated with the waning ENSO cause more frequent swell (long gravity waves) that dislodge kelp holdfasts and generate floating kelp mats at kelp beds on the mainland and channel islands. These mats attract dolphin and this concentration may be a factor in the apparent greater abundance during ENSO periods.

The researchers show that dolphin availability to southern California CPFV anglers will depend on near (small scale, < 200 kilometer [km]) and distant (large scale, > 1000 km) effects. Pacific basin-wide perturbations which weaken or displace the eastern Pacific high-pressure system and lead to less intense California Current forcing and coastal upwelling appear important in allowing dolphin to enter California waters from the south and west. Less intense southward advection of California Current water will allow the subtropical biogeographic boundary to shift northward opening the Southern California Bight to dolphin migration. Seasonal accumulation of warm water near shore and resulting increased northward geostrophic flow facilitates dolphin migration into the Southern California Bight. Once dolphin enter the Bight, upwelling conditions around the seaward banks and islands may be important in producing a cool plume that will limit the dolphin's westward movement and concentrate them in warm water near the mainland, as in 1990. An alternative, but not exclusive, scenario involves partial breakdown of the cool central portion of the southern California eddy, which allows warmer, less-saline California Current water to enter from the west. When dolphin are found in this water, they may be less concentrated as in 1992 and 1993. Coastal-trapped long waves emanating from the south in 1983 and 1992 may have been important in forcing local ocean processes which allowed dolphin to enter the Southern California Bight during these years. (J. Norton, [408] 656-3311)

PFEG Oceanographic and Atmospheric Products Developed to Describe Variability in the Ocean Environment

One important activity of the Pacific Fisheries Environmental Group's physical oceanography task is the development of new techniques and data products which will assist in describing the variability in the ocean environment. Over the years, PFEG has developed routine data products that are distributed widely to researchers and others. Oceanographers David Husby and Jerrold Norton and PFEG Data Manager LTJG Heather Parker process and distribute atmospheric and oceanographic products on a monthly basis as well as maintain archives of the historical data.

The primary source of atmospheric products is U.S. Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC) synoptic surface pressure analyses. The principal wind-driven flow indices are derived from the FNMOC 63x63 northern hemisphere polar-stereographic surface atmospheric pressure fields available at 6-hour intervals. The monthly mean pressure fields are interpolated to both 3- and 5-degree latitude-longitude grids in both the North Pacific and North Atlantic. The wind-driven flow indices include surface pressure, meridional and zonal wind stress, meridional and zonal components of Ekman transport, curl of the wind stress, wind stress divergence, vertical velocity into surface Ekman layer, meridional component of total transport, integrated total transport, and the integrated geostrophic transport. These parameters are available routinely, derived from the monthly mean surface-pressure distributions. In addition, the upwelling index (offshore Ekman transport) is also computed from the monthly mean pressure field at 15 locations along the west coast of the United States.

Upon request, time series of a number of wind-driven flow indices can be calculated at locations in the northern hemisphere at 6-hour, daily, or

Table 1. Standard monthly atmospheric products developed by the Pacific Fisheries Environmental Group, based on U.S. Navy Fleet Numerical Meteorology and Oceanography Center synoptic surface pressure analyses.

Field	Grid	Product
		Statistic/Format
North Pacific 3-degree sea level pressure and wind-driven ocean flow indices	18°-63° N, 130° E-101° W	Monthly mean/listing
North Pacific alternate 5-degree sea level pressure and wind-driven ocean flow indices	15°-65° N, 115° E-100° W	Monthly mean/listing
North Atlantic 3-degree sea level pressure and wind-driven ocean flow indices	9°-72° N, 18° E-102° W	Monthly mean/listing
North Atlantic alternate 5-degree sea level pressure and wind-driven ocean flow indices	15°-65° N, 10° E-105° W	Monthly mean/listing
West Coast Upwelling Index (offshore Ekman transport)	21°-60° N, 15 locations	Monthly mean/table and daily, weekly mean/table with bar graph

monthly intervals. These parameters include sea level pressure, north and east components of wind velocity, north and east components of wind stress, curl of wind stress, cube of wind speed, north and east components of Ekman transport, offshore Ekman transport (upwelling index), and vertical velocity into the Ekman layer. These parameters may be obtained in graphical and/or digital formats. The 6-hour and daily data are available beginning with January 1967 while the monthly data are available beginning with January 1946.

The major oceanographic product produced monthly by PFEG is an extract of all unclassified surface ship weather reports received by the FNMOC on the Global Telecommunication System. These data are sent to the NOAA/Environmental Research Laboratories' Climatic Research Division for inclusion in the Comprehensive Ocean-Atmosphere Data Set (COADS), which is a continuing cooperative project between NOAA and the National Center for Atmospheric Research. From these monthly files of surface weather reports, PFEG creates a file of 1-degree means of sea surface temperature. PFEG routinely produces regional charts of monthly mean sea surface temperature on 1-degree latitude-longitude grids, which include anomalies from long-term monthly means and numbers of reports.

These environmental index products are routinely distributed to some 44 researchers at state, university, and Federal laboratories. In addition, special requests for data products have averaged over 30 per year. Future plans for the data products will include conversion of the data files and programs for automated processing and use by PFEG's planned Information Technology-95 computing system. (D. Husby, [408] 656-3334)

Table 2. Regional sea surface temperature (SST) charts available from the Pacific Fisheries Environmental Group, which give monthly means of SST on 1-degree latitude-longitude grids.

Region	Grid
U.S. West Coast	25°-50° N, 110°-150° W
Alaska	45°-63° N, 122°-180° W
Eastern Pacific	34°-56° N, 117°-180° W
Caribbean	5°-32° N, 60°-100° W
U.S. East Coast	30°-46° N, 60°-99° W

Visiting French Scientists Complete 3-year Stay

The Climate and Eastern Ocean System (CEOS) project is an international collaborative study of the potential effects of global climate change on the living resources of the highly productive eastern ocean upwelling ecosystems and on economic issues directly associated with such effects. A major focus of the study is the clupeoid fishes (anchovies, sardines) that are heavily exploited in the world's large marine ecosystems and which have recently been exhibiting episodes of collapse, rebound, or switches in dominance. Eastern ocean upwelling ecosystems present certain advantages that may make the study of effects of climate change on marine ecosystems particularly tractable; thus, the study may serve an even wider purpose as an illustration of the sorts of impacts that could affect a

variety of more complex marine ecosystems. Scientists from the Pacific Fisheries Environmental Group (PFEG); the Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM); the International Center for Living Aquatic Resources Management (ICLARM); and partners in other institutions, particularly from developing countries, have joined efforts to promote this program which has been funded by NOAA and ORSTOM. Currently, 45 scientists from more than 15 countries are participating in the CEOS network.

The PFEG and ORSTOM component of the CEOS project started in mid-1991 when Philippe Cury and Claude Roy, both from ORSTOM, began their stay at PFEG-Monterey. During this time period, the CEOS project was developed in greater detail, improved international collaboration was organized, several databases were completed, and a variety of research projects were initiated, several of which have been completed. Pelagic fisheries data, environmental data, economic data related to the fisheries, and catch-and-effort statistics from more than 17 countries have been assembled and are now available for the CEOS participants. These databases allow one to study the effect of environmental variability on marine population dynamics, which remains a challenging problem for fisheries science. The impact of decades of environmental change has been analyzed using recently developed nonlinear statistical techniques that extend linear multiple regression analysis. The three techniques used were alternating conditional expectation (ACE), additivity and variance stabilization (AVAS), and generalized additive interactive modeling (GAIM). Empirical results suggest that marine populations will respond to climatic trends but will do so in a nonlinear manner. These nonlinear statistical algorithms, which are not yet widely used in ecology, provide a promising method for exploring the form of the relationships between environmental changes and population responses. These results have been published in several journals and most of them will be synthesized in a book provisionally titled "Global Versus Local Changes in Upwelling Systems."

One major activity of the CEOS network is to promote scientific exchange. Since 1991, Cury, Roy, Operations Research Analyst Roy Mendelssohn, and other colleagues from PFEG organized 14 working groups with some of the CEOS participants. The First International CEOS Meeting will be held in Monterey, California, on September 6-8, 1994, and will be sponsored by NOAA and ORSTOM. During this meeting, the CEOS participants will be able to present the results of their research. Such meetings are tentatively planned every 3 years to promote scientific exchanges between the CEOS participants. (R. Mendelssohn, [408] 656-3333)

Scientists Develop Easily-accessible Ocean-Atmosphere Data Set for Microcomputer

One major goal of the CEOS (Climate and Eastern Ocean System) project is the production of environmental and other databases in forms usable for various scientists in the United States and other countries. Roy Mendelssohn, operations research analyst at the Pacific Fisheries Environmental Group, along with Claude Roy and Philippe Cury of the Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM) have worked collaboratively to develop an easily accessible environmental database for microcomputers. The Comprehensive Ocean-Atmosphere Data Set (COADS) produced by the Cooperative Institute for Research in Environmental Science, NOAA, National Center for Atmospheric Research, and the National Climatic Data Center consists of 100 million surface meteorological observations collected by ships over the world's oceans since 1854. It is one of the most comprehensive, high quality data sets available and it allows one to make worldwide comparative studies of the variability of the environment. In the course of CEOS research, it was noted that the more widely available 2x2-degree monthly summaries of the COADS data set are inadequate for several purposes and that access to the raw observations is needed. The most commonly used version of the raw data—the Compressed Marine Reports, version 5 (CMR5) data set (Release 1)—is presently distributed on either eighteen 6250 bytes-per-inch computer tapes or on several Exabyte tapes. Observations prior to 1970 are grouped by area while observation from 1970 on are grouped by time. These two features make access to, and summarizing of, the raw data quite difficult.

To solve this problem, a microcomputer-based version of the COADS CMR5 (Release 1) has been developed. The CEOS Project will release a set of six CD-ROMs conforming to the International Standards Organization 9660 standard, which will contain the entire CMR5 data set plus a few summaries and maps that have already been extracted from the data set. Software has been written that extracts and summarizes the data by month or year for given ranges of latitude and longitude, by 0.5-, 1.0-, or 2.0-degree squares, or for an entire area. The software can produce summaries for sea surface temperature (SST), air temperature, dew point, the

north-south and east-west components of the wind, and sea level pressure (the parameters contained in the CMR5 format) as well as for scalar wind speed, wind speed cubed, and the two components of the pseudo-wind stress, which are calculated from the raw observations. All the flags in the CMR5 data set that contain information on such things as ship type, estimated reliability of an observation, precision, and measurement device can be set so that only observations with the desired properties are included in a summary. Preliminary analysis of the CMR5 data has shown that if these flags are not carefully chosen, spurious trends often occur when analyzing the data. Using the COADS data, time series of wind, SST, and other environmental parameters were constructed for the world's main upwelling areas. A comparative analysis of the climatic variability in each of these areas was conducted using recent advances in state-space modeling and related techniques. These techniques allow us to estimate nonparametric trends for the time series, time-varying (nonstationary) seasonal cycles, and time-varying (nonstationary) spectral estimates. Statistical tests for significant changes in level and constancy in the seasonal cycle allow us to examine whether significant "regime changes" have occurred. Models that estimate common trends or seasonal cycles in the data are used to attempt to separate local from global variation.

Limited distribution of the COADs on CD-ROM will be available; the users' manual will be published by ORSTOM. (R. Mendelssohn, [408] 656-3333)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

PELAGIC ECOSYSTEM MODEL DEVELOPMENT PROGRAM

45th Tuna Conference Held at Lake Arrowhead

The 45th Tuna Conference was held at the University of California's Lake Arrowhead Conference Center May 23-26, 1994. The theme for the Conference, "Movement and Migration," attracted an unusually large number of papers. In all, there were 45 presentations, 26 of which were included in a session on tuna distribution, movement, and migration. The remaining presentations were distributed in sessions dealing with the tuna-dolphin situation, biological aspects, and activities and status of fisheries. Nine of the presentations were poster displays.

Included in the conference was a special session on archival tags. The archival tag concept is rapidly emerging as a powerful tool for studying migration of highly migratory species. An archival tag is designed around using a microprocessor that controls acquisition and storage of data from sensors measuring a field of parameters as the fish migrates. This special session reviewed progress in development of archival tags, and a round table discussion on future directions was held.

Two scholarships were awarded this year for student papers. The recipient of the Tuna Conference Scholarship was Daniel Scoles of the Virginia Institute of Marine Sciences for his paper on the phylogeography of mackerels using mitochondrial DNA. The Manuel Caboz Memorial Scholarship recipient was Laurent Dagorn, a student at the Ecole Nationale Superieure Agronomique de Rennes working at the Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), who presented results of his theoretical studies on tuna movement and schooling behavior.

The annual Tuna Conference is sponsored jointly by the Inter-American Tropical Tuna Commission and the Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service. This year's host organization was the SWFSC. Additional organizations contributing to events at the 45th Conference were the Japan Tuna Fisheries Cooperative Association (Nikkatsuren); the University of California, Los Angeles; Lake Arrowhead Conference Center; Northwest Marine Technology, Inc.; and the United States Tuna Foundation.

A copy of the conference proceedings may be obtained by contacting the Tuna Conference co-chairmen Pierre Kleiber or Rand Rasmussen. (P. Kleiber, [619] 546-7076)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

1993 U.S. Pacific Albacore Troll Fisheries Summarized

Fishery Biologist John Childers presented a poster paper titled "Summary of the 1993 U.S. Pacific albacore troll fisheries" at the 45th Annual Tuna Conference held at Lake Arrowhead, California,

May 23-26, 1994. A summary of the paper is as follows:

U.S. troll vessels have fished for albacore in the North Pacific since the 1950s, expanding the range of the traditional fishing grounds from within 50 nautical miles of the U.S. west coast to an area extending from the coast to west of the international dateline. The North Pacific albacore fishing season usually begins between late May and mid-July and lasts until late October or early November. Between 200 and 600 vessels participate in this fishery. The United States began fishing for albacore in the South Pacific in 1986. The southern fishery normally begins in late December and lasts through early April, with the fleet consisting of 40 to 60 troll vessels. Since the 1990-91 fishing season, total U.S. landings of albacore from the South Pacific fishery have declined while landings from the North Pacific fishery have increased.

Total landings for the 1992-93 U.S. South Pacific albacore fishery reached an all-time low of 1,030 metric tons (t), 66 percent less than landings for the 1991-92 season. Average catch rate for this fishery has similarly been declining since the 1989-90 fishing season. In 1992-93, the average catch rate dropped to 45 fish per day (17-percent sampling coverage) from 72 fish per day (60-percent sampling coverage) in 1991-92. During the 1992-93 season, a total of 1,720 fish were sampled for fork lengths (0.87-percent sampling coverage). The average fork length was 63 centimeters (6.9 kilograms [kg]). A dominant mode occurred at the 60-cm length class, and a weaker secondary mode at 69-cm fork length. Overall, fish were smaller than in past seasons.

U.S. troll landings of albacore from the North Pacific have historically fluctuated but have exhibited a general declining trend from 1984 through 1991. Landings have been increasing annually since 1991, reaching 5,578 t in 1993, up 22 percent from the 4,572 t landed in 1992. Average catch rate for U.S. troll vessels has also fluctuated. The average catch rate was 38 fish per day in 1993 (21-percent sampling coverage)—a decrease from 54 fish per day (38-percent sampling coverage) in 1992. A total of 10,885 albacore in the catch were sampled for fork lengths in 1993 (1.3-percent sampling coverage). The average length was 69 cm (6.8 kg), up 27 percent from the 1992 average length of 63.7 cm (5.4 kg). The length frequency distribution showed two distinct modes centered at 64 cm (5.4 kg) and 74 cm (8.4 kg). (J. Childers, [619] 546-7192)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Off-California Shark Populations Studied

Fishery Biologist Darlene Ramon participated in a cooperative research cruise with the California Department of Fish and Game (CDF&G) aboard the research vessel *Mako* from June 13 to 17, 1994. The purpose of the cruise was to longline mako, thresher, and blue sharks in the Southern California Bight and to study shark abundance. This was the first of three research cruises scheduled for the year to study the shark population off southern California. The second, July 11-24, will be aboard the research vessel *David Starr Jordan*. The third cruise will be aboard *Mako* and will involve Southwest Fisheries Science Center and CDF&G scientists.

During the first cruise, the longline gear was deployed for 4 sets, totaling 368 hooks. A total of five blue sharks, two mako sharks, and seven pelagic stingrays were caught. All seven sharks were in good condition when caught and were tagged and released. The stingrays were also released. Catch-per-unit effort rates were 1.3 fish/100 hooks for blue sharks and 0.5 fish/100 hooks for mako sharks. (D. Ramon, [619] 546-7074)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH COMMUNITIES INVESTIGATION

Faunal and Floral Changes Monitored with Ocean Warming off Southern California

Changes in the fauna and flora of a southern Californian marine habitat have been monitored by the Groundfish Communities Investigation for the past 22 years. The habitat at Santa Catalina Island was the site of an intensive investigation of ecological relations by Fishery Biologists Ted Hobson and Tony Chess from 1972 to 1975. That study defined the community in great detail and, therefore, represented a basis for monitoring changes that have developed with the ocean warming that began in 1976. With subsequent assessments centered on a transect established in 1972, Hobson and Chess were joined in 1981 by Fishery Biologist Dan

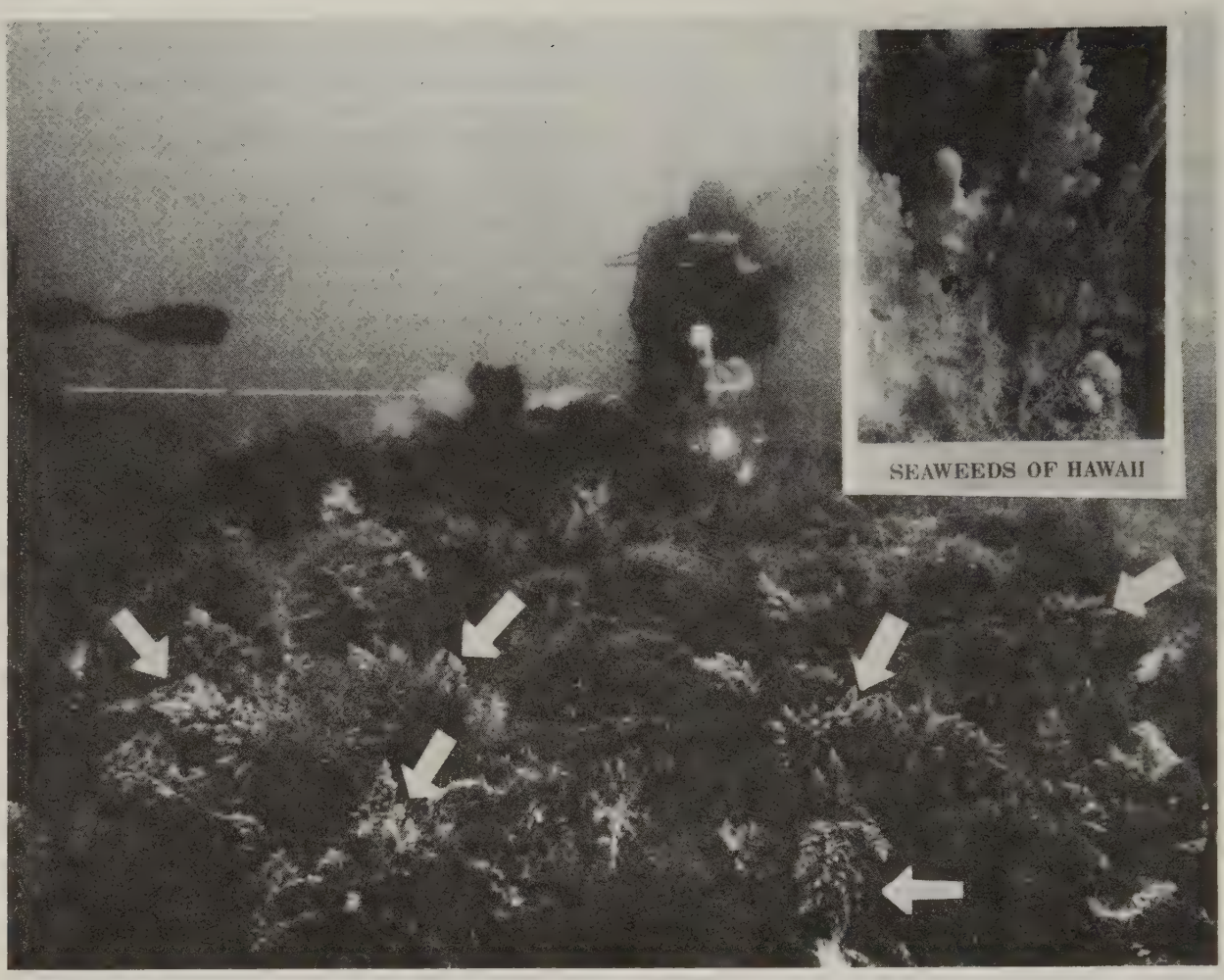

Figure 1. Tiburon biologist assessing benthos at Santa Catalina Island, off California. Arrows point to patches of the alga *Asparagopsis taxiformis*. Inset is cover from book on Hawaiian algae, which portrays this species as it occurs in that tropical habitat.

Howard to document the many progressive changes that have developed in the community.

Changes in coverage by the giant kelp *Macrocystis pyrifera* have been widely reported by numerous investigators, but changes to the benthic turf have been less evident and generally little recognized. During the 1972-75 study, the transect turf was mainly *Dictyopteris undulata* and, in fact, a publication by Hobson and Chess in 1976 based on results of that earlier work referred to this turf as a "*Dictyopteris*" field. In the study area on leeward Santa Catalina, this alga went into a decline during the late 1970s and is now only a minor component of the turf (3 percent of the coverage in the transect). The dominant alga in the transect benthos now is *Sargassum palmeri* (covering 55 percent of the bottom), which is not exactly a "turf alga" but nevertheless carpets the sea floor in places. A striking addition to the turf in the study area is *Asparagopsis taxiformis* (Fig. 1). This species, a tropical form common in the Gulf of California but considered rare off California, was not seen in the study area until 1992. Since then, however, it has rapidly gained in prominence.

There has been a similar occurrence in the fauna with what seems to be an undescribed species of the gammaridean amphipod genus *Paradeximine*. Although prominant in the western Pacific, this genus has not previously been reported from the western hemisphere. Nevertheless, since its initial occurrence in samples collected by the Tiburon Laboratory during 1988, it has steadily increased in

numbers until it is now one of the dominant amphipods (105.7/0.25 square meters [m^2] of rock substrata).

Many progressive changes in the fauna have mirrored the pattern of change in sea temperature, that is, the sharply increased temperatures during the early 1980s, followed by cooling late in that decade and the more recent warming. Among these is the gammaridean amphipod, *Batea transversa*, and the ascidean *Tridemnum opacum* (Fig. 2). There has also been apparent replacement of species by close relatives. Thus, the gammaridean amphipod Podocerus cristatus was a dominant form during the early 1970s but declined with the increasing sea temperatures while a congener, P. brasiliensis, gained prominence (Fig. 3). (E. Hobson, J. Chess, and D. Howard, [415] 435-3149)

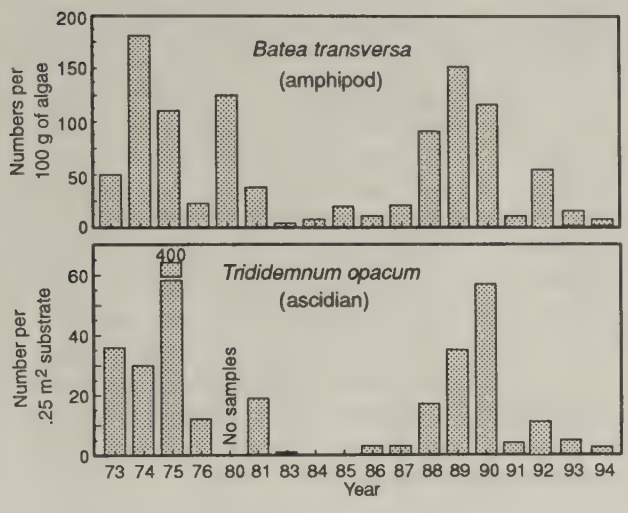

Figure 2. Numbers of gammaridean amphipod *Batea transversa* and ascidean *Tridemnum opacum* found in the habitat at Santa Catalina Island, off California, 1973-1994.

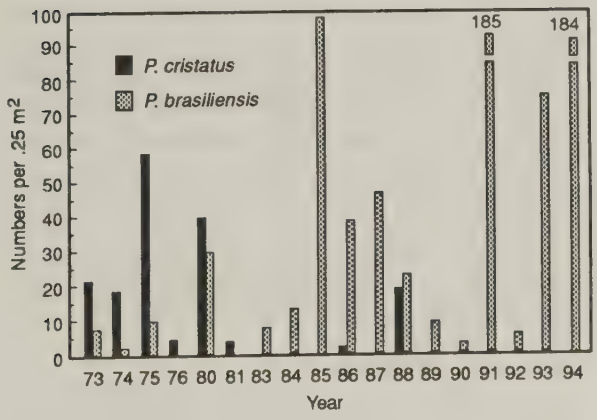

Figure 3. Numbers of gammaridean amphipods *Podocerus cristatus* and *P. brasiliensis* found in the habitat at Santa Catalina Island, off California, 1973-1994.

GROUNDFISH ANALYSIS INVESTIGATION

Groundfish Analysis Staff Completes 12th Annual Survey of Juvenile Rockfish

Fishery biologists working in the Groundfish Analysis Task at Southwest Fisheries Science Center's Tiburon Laboratory have successfully completed their 12th annual juvenile rockfish, *Sebastes* spp., survey (DSJ-94-06). The research, designed to assess the distribution and abundance of pelagic young-of-the-year rockfish inhabiting the coastal waters off central California, was conducted from May 18 to June 22, 1994, aboard NOAA's research vessel *David Starr Jordan*.

A modified Cobb midwater trawl with a 26.22-meter headrope and 1.27-centimeter codend was used to capture the 12- to 54-millimeter standard length (mm SL) juveniles at 36 stations along seven transects situated between Cypress Point (Monterey Bay) and Point Reyes (north of San Francisco) and to a distance of about 80 kilometers offshore. Three "sweeps" of the survey area were made. The trawls, conducted at night, were fished for 15 minutes at each station. Most trawls were fished at a headrope depth of 32 meters or at 8 meters in shallow water.

During daylight hours, conductivity-temperature-depth casts were conducted to measure temperature and salinity at depth. In addition, sea-surface temperature (SST) and salinity were recorded continuously for the duration of the cruise. A plot of the SST during Sweep II (Fig. 4) reveals the cold upwelled water that was prevalent during the survey.

Compared with previous surveys, the juvenile rockfish catch was the lowest since repetitive sampling of the survey area was initiated in 1986 (Table 1). In fact, a strong year-class of shortbelly rockfish, a species that typically dominates the catch, has not been observed since 1988. These differences in abundance will be further magnified when catches are adjusted to a standard age (100 days) due to the extremely small size of the fish; almost all the fish were less than 20 mm SL. Previous work on the daily growth of these fish indicates that they were

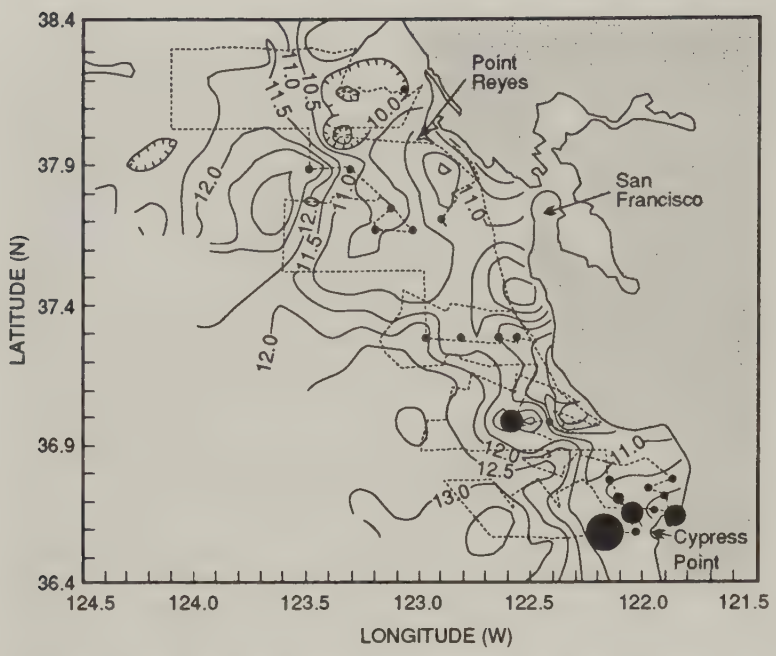

Figure 4. Contours of sea surface temperature measured by conductivity-temperature-depth casts and the catch of juvenile rockfish taken by Cobb midwater trawl during sweep II (DSJ-94-06) of the 12th annual juvenile rockfish survey, conducted from May 18 to June 22, 1994. Dark circles (from very small to very large) represent catch data (1-46 rockfish). Straight lines depict cruise track. Contours with hatch marks represent cooler waters.

released as larvae in April, several months after the usual peak parturition period of January-February. The absence of larger fish is hypothesized to be the result of conditions coincident with anomalous warm SSTs from January to mid-April, a critical time for larval survival. Upwelling was initiated in mid-April and was very strong during the survey period. However, it appears that the spring transition to favorable upwelling conditions occurred too late to benefit the 1994 year-class.

In addition to the standard collection of juvenile rockfish, a large number of additional specimens were collected for other researchers from several organizations. (D. Woodbury and S. Ralston, [415] 435-3149)

GROUNDFISH PHYSIOLOGICAL & ECOLOGY INVESTIGATION

Reproductive Life History of Shortbelly Rockfish Studied

Of the 83 managed fish species in the Pacific coast groundfish fishery, 55 are rockfish species, genus *Sebastes*. They comprise 44 percent of the total recent groundfish average yield, excluding whiting (when whiting is included in the average yield, the 55 rockfish species' total percentage drops to 13 percent). Most major west coast groundfishes are fully harvested. Only the shortbelly rockfish is classified as underutilized with an above-average stock level status. Although there is no developed market for this species, the Pacific Fishery Management Council has set a harvest guideline of 23,500 metric tons.

To complement previous stock assessments obtained from hydroacoustic surveys, recent efforts have been made to estimate spawning biomass using the larval production method. Knowledge of the reproductive life history of the shortbelly rockfish is required to complete this assessment. Studies began in 1990 that included adult and larval surveys along central California from the Monterey Canyon area north to Bodega Canyon. Bongo net ichthyoplankton tows and midwater trawls were done from a combination of chartered commercial fishing vessels and the NOAA research vessel *David Starr Jordan*.

One area of emphasis in these studies is the estimation of fecundity. Program staff are currently in the fourth year (reproductive year 1993/1994) of collection, with a total of 832 fecundity specimens collected. Of these, 532 fish from the first three years have been examined and their fecundities estimated. The sampled population is representative of the general population as indicated by its full range of ages and sizes (Table 2). Ages of the fish covered the known range of the reproductive life span and were variable as indicated by a coefficient of variation of 75 percent. Nonetheless, the mean age was 6 years.

Absolute fecundity (Y, eggs) generally increased in a linear fashion with body weight (X, g) and fits the general linear model

$$Y = -1446 + 117.98\,X,\ r^2 = 0.71. \quad (1)$$

While the above relationship described how the total number of eggs increased with increasing body size, the relative fecundity, or number of eggs per unit of body weight (Z, eggs/g), did not

Table 1. Number of pelagic young-of-the-year rockfish collected in coastal waters off central California by midwater trawl at standard stations and depths during May-June cruises (1986-1994).

Species	1986	1987	1988	1989	1990	1991	1992	1993	1994
Shortbelly	9104	6865	107,962	1598	4479	2422	2838	2287	966
Chilipepper	54	586	4418	24	66	343	90	1251	3
Brown	470	10	-	3	19	265	7	1226	17
Widow	11	424	257	13	296	623	1	101	23
Squarespot	4	177	380	16	649	47	70	25	-
Canary	46	71	162	39	23	618	-	14	3
Blue	4	196	366	63	38	220	-	37	11
Stripetail	2	194	30	6	22	175	5	315	9
Bocaccio	327	106	60	22	44	114	5	26	4
Yellowtail	22	85	69	31	27	281	5	31	7
Copper complex	9	9	1	-	1	15	116	82	2
Pygmy	2	15	9	12	10	62	8	2	3
Halfbanded	1	9	-	2	77	8	1	5	2
Black	1	22	19	5	4	34	-	6	2
Olive	-	4	2	6	18	-	-	6	1
Darkblotched	-	7	5	-	1	9	-	9	-
Cowcod	1	17	1	1	-	-	5	5	-
Bank	-	18	4	-	-	-	-	5	-
Splitnose	1	4	-	-	1	-	19	-	-
Sebastomus	2	7	3	-	1	3	8	-	-
Puget Sound	-	-	-	-	-	22	-	-	-
Sharpchin	-	-	-	-	-	18	2	-	-
Grass	1	1	-	-	-	-	8	2	-
Quillback	2	1	-	-	-	6	-	-	-
Vermilion	-	4	-	-	1	1	-	-	-
Greenstripe	-	3	-	-	-	-	-	-	-
Tiger	3	-	-	-	-	-	-	-	-
China	-	2	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	1	-	-
Greenspotted	-	-	-	-	-	-	1	-	-
Unknown	37	-	-	-	2	4	49	31	84
Totals	10,104	8837	113,748	1841	5779	5290	3242	5466	1137

Table 2. Summary of ages, standard lengths, total body wet weights, and absolute and relative fecundities of shortbelly rockfish from reproductive seasons 1990/91 to 1992/93. Data collected in adult and larval surveys along central California from the Monterey Canyon area north to Bodega Canyon.

Variable	Mean	Standard Deviation	Minimum	Maximum
Ages (years)	6.0	4.5	1.0	23.0
Standard length (cm)	19.8	3.8	13.0	26.5
Wet weight (g)	132.2	73.7	29.4	297.5
Absolute fecundity (eggs)	14,067.0	12,275.0	631.0	77,367.0
Relative fecundity (eggs/g)	101.6	53.0	14.0	370.2

significantly change with increasing body size. Rather, the linear regression equation for this relationship was

$$Z = 82.1 + 0.163\,X,\ r^2 = 0.20. \quad (2)$$

The slope was not statistically significant. This implies that the egg concentration remains relatively constant throughout the reproductive life of the shortbelly rockfish, unlike patterns that were observed in yellowtail rockfish. (M. Eldridge, [415] 435-3149)

Investigation Staff Participates in 1994 Shortbelly Rockfish Research Cruises

During June 1994 staff of the Physiological Ecology Investigations conducted trawl and plankton net surveys from the NOAA research vessel *David Starr Jordan* in three submarine canyon areas off central California. The twofold purpose of this effort was, first, to collect larval and young-of-the-year juvenile specimens of the shortbelly rockfish, *Sebastes jordani*, for assessment of physiological condition and, second, to survey adult populations to determine their reproductive states.

After completion of 17 midwater trawls in Bodega Canyon and Pioneer Canyon, juvenile shortbelly rockfish were found to be very low in abundance and patchy in distribution. Specimens were frozen at -70 °C for later analyses that will focus on total lipid content and lipid-class composition, partial measures of physiological condition, and viability.

Bongo plankton nets were also towed to determine whether female shortbelly rockfish were releasing larvae. No larvae were found in the northernmost Bodega Canyon while a limited number of post-flexion larvae were collected in the Pioneer Canyon area.

Adult shortbelly rockfish were caught in 7 of 10 trawls made in the 3 canyons. Catches ranged from approximately 50 to 3,600 kilograms and showed a consistently even male/female sex ratio of 0.54. Examination of the reproductive state of the fish supported earlier findings from the plankton catches that the 1993/1994 reproductive season has ended. Female gonads were mostly in a recovery/reorganization condition. Less than 5 percent of the specimens showed evidence of spawning within the last month. Male specimens were in the initial stages of ripening and recrudescence. To further monitor the annual reproductive cycle, arrangements have been made to obtain adult specimens from commercial bycatches. (M. Eldridge and E. Norton, [415] 435-3149)

INFORMATION TECHNOLOGY SERVICES

National Data Management Committee Meets in La Jolla

Information Technology Services (ITS) hosted the 3-day National Data Management Committee (NDMC) meeting May 3-5, 1994, in La Jolla, California. The Regional Area Data Base Administrators (RDBA) who attended the 3-day sessions were Chairperson MaryAnne Camp (Southeast Fisheries Science Center), Eugene Heyerdahl (Northeast Fisheries Science Center), Ted Rodgers (Alaska Fisheries Science Center), John Landahl (Northwest Fisheries Science Center), and Dorothy Roll (Southwest Fisheries Science Center [SWFSC]). The other participants were Gaylen Tromble (Alaska Region) and Michael Fraser, Hugh Johnson, Mark Holliday, and Craig Felber from NMFS Headquarters. Rob Bistodeau (SWFSC) attended these meetings as the official recorder. Two of the key issues discussed for recommendations by consensus were the Reinvention of the NDMC and the IT-95 Wide Area Network (WAN) Plan.

In response to a request from Rolland Schmitten, NMFS Assistant Administrator for Fisheries, the outdated 1977 charter of the NDMC was examined and evaluated. The committee formulated a new charter with recommendations for membership, a new name, frequency of meetings, and responsibilities. The recommendations will be proposed to the Board of Directors (BOD) for their decision as to the fate, structure, and responsibilities of this committee.

A planning session was devoted to the NMFS Information Technology 95 (IT-95) WAN. Derek Favila (NMFS Network Control Center), Jerry Hornof (data manager/coordinator Southwest Region), and Frank Ralston and Matt Bones (SWFSC) participated in this session. The group discussed various options for future internetworking, the costs, and the management requirements for maintaining both Internet and IT-95 WAN connectivity. As a result of the discussions on the IT-95 WAN plan, two proposals will be developed and recommended for presentation to the BOD. One proposal will be based on the $500,000 available funding for implementing interconnectivity of the IT-95 host sites and the links within each regional site. The other proposal will be interconnectivity that

achieves optimum data transfer rates without the budget constraints. Each regional site will develop their WAN configurations for submission to IT-95 Project Manager Hugh Johnson, who will incorporate them into the proposed master plans. Before the master plans are finalized for submission to the BOD, the drafts will be given to regional directors and science directors for their review and comments. (D. Roll, [619] 546-7057)

PUBLICATIONS

Published

Aguirre, A. A., G. H. Balazs, B. Zimmerman, and T. R. Spraker. 1994. Evaluation of Hawaiian green turtles (*Chelonia mydas*) for potential pathogens associated with fibropapillomas. J. Wildl. Dis. 30(1):8-15.

Atkinson, S., B. L. Becker, T. C. Johanos, J. R. Pietraszek, and B. C. S. Kuhn. 1994. Reproductive morphology and status of female Hawaiian monk seals (*Monachus schauinslandi*) fatally injured by adult male seals. J. Reprod. Fertil. 100:225-230.

Female Hawaiian monk seals at Laysan Island in the Northwestern Hawaiian Islands seasonally are subjected to aggressive mating attempts by groups of adult male monk seals. These attacks, which also target immature female and male seals at a lower frequency, result in injuries that are often fatal and termed mobbings. This study was undertaken to assess the reproductive status of nine female seals that died after mobbing attacks and to obtain basic morphological data of reproductive tracts from 10 females. Reproductive morphology of the seals indicated that the lengths of the uterine body and both uterine horns were significantly shorter in nulliparous than in parous seals. Seven of the nine seals were periovulatory, on the basis of gross morphology of the ovaries at death. The ovaries of the other two seals possessed immature follicles. Histological studies of the vagina and uterus confirmed the reproductive status of the seals. When the reproductive status at the time of first injury was estimated, all seals were in the follicular phase of the oestrous cycle. At least four of these seals were estimated to be in oestrus at the time of their first injury, and seven of the seals sustained at least one injury during the estimated period of oestrus (2-6 days). These results support the hypothesis that most adult female Hawaiian monk seals that die following an attack by male monk seals are periovulatory and that the majority of the attacks occur during oestrus.

Balazs, G.H., and S.G. Pooley. 1994. Research plan to assess marine turtle hooking mortality: Results of an expert workshop held in Honolulu, Hawaii, November 16-18, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-201, 166 p.

Barlow, J. 1994. An assessment of the 1994 status of harbor porpoise in California. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-205, 17 p.

————————. 1994. Recent information on the status of large whales in California waters. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-203, 27 p.

The structure, size, growth, and status of whale populations is reviewed for species that are found in California waters. Humpback whales in the North Pacific are thought to have been severely depleted by historic whaling. The humpback whale stock which feeds in summer/fall from California to Washington is estimated to number 581 (coefficient of variation [C.V.] = 0.03) based on mark-recapture estimates from a minimum of 482 individual whales identified in a 1991-92 photoidentification study. Blue whales and fin whales were also depleted by whaling in the North Pacific, but probably not as severely as humpback whales. The blue whale stock which feeds in California during summer/fall numbers approximately 2,250 (C.V. = 0.38; 95% C.I. = 1,093-4,632), and the fin whale stock which may be resident in California numbers approximately 935 (C.V.=0.63; 95% C.I. = 299-2,925). Sei whales are believed to be severely depleted in the North Pacific and are now rare in California. Bryde's whales were not severely depleted in the eastern Pacific but are also rare in California. Minke whales in California number approximately 526 (C.V. = 0.97; 95% C.I. = 106-2,596) and appear to be resident there. Minke whales were never subject to commercial whaling in the eastern Pacific. The sperm whale stock in the eastern North Pacific is very large and may not have been reduced much by commercial whaling. Sperm whale abundance in California is estimated as 756 (C.V. = 0.49; 95% C.I. = 303-1,886). Right whales were severely depleted by historic whaling and are nearly extinct in the North Pacific. Sightings of right whales in California are rare and noteworthy events. All of the whales except minke whales and Bryde's whales are formally listed as "endangered" under the U.S. Endangered Species Act. All suffer some human-caused mortality from drift gillnets and ship strikes in California.

Blood, D. M., A. C. Matarese, and M. M. Yoklavich. 1994. Embryonic development of walleye pollock, *Theragra chalcogramma*, from Shelikof Strait, Gulf of Alaska. Fish. Bull., U.S. 92:207-222.

Eggs of walleye pollock, *Theragra chalcogramma*, from Shelikof Strait, Alaska, were reared at three temperatures: 3.8, 5.7, and 7.7 °C. Development was divided into 21 stages. A piece-wise regression model with midpoints of each stage describes the relation between time to each stage of development and temperature. Preserved eggs of each stage are described, illustrated,

and photographed. Midpoint of hatch was 393 hours at 3.8 °C, 303 hours at 5.7 °C, and 234 hours at 7.7 °C. Mean length of larvae at hatch increased linearly with temperature. The scientists compared rate of development, time to 50 percent hatch, and morphological development with other studies of walleye pollock eggs. Rate of development and time to 50 percent hatch were similar among populations of eastern North Pacific walleye pollock. Western North Pacific walleye pollock required longer incubation times than eastern North Pacific walleye pollock. Morphological development of Shelikof Strait eggs differs from development of western North Pacific walleye pollock eggs: optic vesicles, myomeres, eye lenses, heart, and olic capsules appear earlier than in Shelikof Strait eggs, and eye pigment appears later. The differences in development may be exacerbated by the condition of the eggs in which they were examined (for example, preserved vs. live). Developmental differences between stocks are discussed with the conclusion that model components for egg mortality and spawning biomass must be based on specimens collected in the area of interest.

Boehlert, G. W. 1994. Fisheries and marine resources of Hawaii and the U.S.-associated Pacific Islands: an introduction. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):3-6.

The fisheries of Hawaii and other U.S.-associated islands in the Pacific Ocean are characterized by high diversity, both in the species exploited and the human cultures that exploit them. The commercial sector has undergone rapid growth in recent years, but recreational and subsistence sectors remain important. Information on these fisheries is generally not available in published form. Boehlert presents an overview and introduction to a volume of papers describing fisheries in the region, with the goal of making the information available to scientists and the general public. A great deal remains to be learned about the dynamics of these fisheries as well as the associated issues in biological research, fisheries management, and environmental protection.

———. 1994. The fisheries of Hawaii and U.S.-associated Pacific Islands (Preface). *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):1-2.

Boehlert, G. W., and B. C. Mundy. 1994. Vertical and onshore-offshore distributional patterns of tuna larvae in relation to physical habitat features. Mar. Ecol. Prog. Ser. 107:1-13.

The seasonal and spatial distribution of larval scombrids in waters off Oahu, Hawaii, were studied in September and December 1985 and April and June 1986 to determine vertical and onshore-offshore patterns. Horizontal distribution was resolved by sampling transects of three stations on the windward and leeward sides of the island. Vertical distribution was resolved by sampling using a multiple opening/closing net and environmental sensing system (MOCNESS) and Manta nets at the two nearshore stations and in nine depth strata at the four offshore stations. The scientists found that the high concentrations of scombrid larvae near islands, particularly Thunnus spp., suggest that the high concentrations may be related to habitat characteristics that promote higher larval survival than in oceanic waters.

Boggs, C. H. 1993. Methods for analyzing interactions of limited-range fisheries: Hawaii's pelagic fisheries. *In* Shomura, R. S., J. Majkowski, and S. Langi (eds.), Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries, Noumea, New Caledonia, Volume 1: Summary Report and Papers on Interaction, p. 74-91. FAO Fisheries Technical Paper No. 336.

Boggs, C. H., and R. Y. Ito. 1994. Hawaii's pelagic fisheries. *In* G.W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):69-82.

Hawaii's diverse pelagic fisheries supply the bulk of the state's total catch. The largest Hawaii fishery is the recently expanded longline fishery, which now lands about 4,400 metric tons (t) of broadbill swordfish, *Xiphias gladius*; 1,500 t of bigeye tuna, *Thunnus obesus*; and 3,000 t of other pelagic species annually. The increased catch of these other species has raised concerns regarding the continued availability of yellowfin tuna, *T. albacares*; blue marlin, *Makaira mazara*; and mahimahi, *Coryphaena hippurus*, in the small-vessel troll and handline fisheries that target those species.

Analysis of catch-per-unit effort (CPUE) statistics from Hawaii's fisheries did not provide strong evidence of recent declines in availability related to local fishery expansion. A more influential factor was variation in Pacific-wide CPUE, representing overall population abundance and catchability. Exogenous factors, including Pacific-wide fishing pressure, may overwhelm the influence of local fishing pressure on fish availability.

Boggs, C. H., and B. S. Kikkawa. 1994. The development and decline of Hawaii's skipjack tuna fishery. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):61-68.

The pole-and-line fishery for skipjack tuna, *Katsuwonus pelamis*, was the largest commercial fishery in Hawaii until its decline in the 1970s and 1980s. The development and decline of the fishery were strongly affected by fish availability and marketing. A sustained drop in the availability of large fish in the mid-1970s appears to have been due in part to a sustained environmental change. Availability of large fish subsequently increased, but the fishery continued its decline due to low profitability and lack of markets. The tuna cannery in Honolulu that fostered

the fishery's expansion in the 1930s closed in 1984. Unless efforts to increase the market for skipjack tuna become effective, landings will probably remain at current levels of about 1,000 metric tons per year. The existing pole-and-line fleet may continue to decline with age, and the local market may eventually be supplied by other fishing methods (for example, trolling), by new vessels, or by imports.

Brill, R. W., H. Dewar, and J. B. Graham. 1994. Basic concepts relevant to heat transfer in fishes, and their use in measuring the physiological thermoregulatory abilities of tunas. Environ. Biol. Fishes 40:109-124.

Aerobic heat production and heat loss via the gills are inexorably linked in all water-breathing teleosts except tunas. These processes are decoupled in tunas by the presence of fascular counter-current heat exchangers, and sustained muscle temperatures (that is, steady state) may exceed water temperature by 10 °C or more in larger individuals. The presence of vascular counter-current heat exchangers is not clearly advantageous in all situations, however. Mathematical models predict that tunas could overheat during strenuous activity unless the efficacy of vascular heat exchangers can be reduced and that they may be actively limited in warmer waters. Tunas may likewise be forced out of potentially usable habitats as they grow because they have to occupy cooler waters. Vascular counter-current heat exchangers also slow rates of heating and cooling. A reduced rate of muscle temperature decrease is clearly advantageous when diving into colder water to chase prey or avoid predators. A reduced rate of heat gain from the environment would be disadvantageous, however, when fish return to the warmer surface waters. When subjected to changes in ambient temperature, tunas cannot defend a specific body temperature and do not thermoregulate in the mammalian sense. Yet when appropriately analyzed, data taken under steady state and non-steady state conditions indicate that tunas are not strictly prisoners of their own thermoconserving mechanisms. They apparently can modify overall efficiency of their vascular counter-current heat exchangers and thus avoid overheating during bouts of strenuous activity, retard cooling after diving into colder water, and rapidly warm their muscles after voluntarily entering warmer. The exact physiological mechanisms employed remain to be elucidated.

Brill, R. W., and D. R. Jones. 1994. The influence of hematocrit, temperature and shear rate on the viscosity of blood from a high-energy-demand teleost, the yellowfin tuna, *Thunnus albacares*. J. Exp. Biol. 189:199-212.

The high cardiac output, arterial blood pressure, and cardiac energy demand of tuna make it likely that blood viscosity has an important influence on cardiovascular function. Furthermore, tuna regularly subject themselves to ambient temperature changes of 10 °C or more during their daily vertical migrations. They can also maintain muscle temperatures several degrees Celsius above ambient and reach maximum muscle temperatures of approximately 15 °C above ambient. The blood of tuna is, therefore, subjected to more frequent and rapid temperature changes than those that occur in other teleosts. Nothing is known, however, about the effects of temperature, shear rate, or hematocrit on the viscosity of tuna blood.

Viscosity of yellowfin tuna blood (hematocrits of 0-55 percent) was measured at 15, 25 and 35 °C and at shear rates of 45, 90, 225 and 450 s^{-1} using a cone-plate viscometer. As found for the blood of other vertebrates, viscosity increased with increasing hematocrit. Viscosity also increased nonlinearly with decreasing shear rate, until a shear rate of 90 s^{-1} was reached. There was no significant increase in viscosity when shear rate was decreased further to 45 s^{-1}. Because of the relatively flat hematocrit-viscosity curves, predicted optimal hematocrit curves were nearly flat above a hematocrit of approximately 30 percent.

Carretta, J. V., M. S. Lynn, and C. A. LeDuc. 1994. Right whale (*Eubalena glacialis*) sighting off San Clemente Island, California. Mar. Mamm. Sci. 10(1):101-105.

Craig, P., B. Ponwith, F. Aitaoto, and D. C. Hamm. 1994. The commercial, subsistence, and recreational fisheries of American Samoa. *In* G.W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):109-116.

Domestic fisheries in American Samoa landed 587,000 pounds of fish and invertebrates in 1991, worth $993,000. Most of the catch (78 percent) and value (80 percent) was taken by the shoreline subsistence fishery that occurs on the coral reefs surrounding the islands. Artisanal fisheries for offshore pelagic fishes (primarily skipjack tuna, *Katsuwonus pelamis*, and yellowfin tuna, *Thunnus albacares*) and bottomfishes (snappers, emperors, groupers) accounted for 16 and 3 percent, respectively, of the domestic catch. Recreational tournament catches for pelagic fishes represented the remainder (3 percent). While sport fishing is becoming increasingly important, other domestic fisheries have declined in recent years. The shoreline subsistence fishery has dropped by about 25 percent over the past decade due to socioeconomic factors and possibly overexploitation. Artisanal fisheries have also declined precipitously in recent years due to hurricane-related damages, attrition of fishermen, and competition with imports. Artisanal fisheries show some potential for growth but may be constrained by marketing issues, vessel capabilities, and limited stock sizes (for bottomfish) or local availability of high-value (pelagic) fishes.

In contrast to the small-scale domestic fisheries, American Samoa is also homeport to a distant-water fleet of large purse seiners and longliners that fish beyond the exclusive economic zone and deliver about 160,000-220,000 short tons of tuna per year to local canneries.

DeMartini, E. E., K. C. Landgraf, and S. Ralston. 1994. A recharacterization of the age-length and growth relationships of Hawaiian snapper, *Pristipomoides filamentosus*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-199, 14 p.

Dizon, A. E., W. F. Perrin, and P. A. Akin. 1994. Stocks of dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific: a phylogeographic classification. NOAA Technical Report NMFS 119.

Finn, M. A., and M. A. Rice. 1994. Hawaiian monk seal observations at Necker Island, 1993. 'Elepaio 55:7-10.

Forney, K.A. 1994. Recent information on the status of odontocetes in Californian waters. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-202, 87 p.

Frazier, J. G., H. L. Fierstine, S. C. Beavers, F. Achaval, H. Suganuma, R. L. Pitman, Y. Yamaguchi, and C. M. Prigioni. 1994. Impalement of marine turtles (Reptilia, Chelonia: Cheloniidae and Dermochelyidae) by billfishes (Osteichthyes, Perciformes: Istiophoridae and Xiphiidae). Environ. Biol. Fishes 39:85-96.

Gilmartin, W. G., T. C. Johanos, and L. l. Eberhardt. 1993. Survival rates for the Hawaiian monk seal (*Monachus schauinslandi*). Mar. Mamm. Sci. 9(4)407-420.

Endangered Hawaiian monk seal (*Monachus schauinslandi*) pups at all the major breeding islands in the Northwestern Hawaiian Islands have been tagged since the early 1980s. Pups were double flipper tagged as soon as possible post-weaning. With few exceptions, an extensive tag resighting effort was conducted annually at the same islands. These resighting data were used to estimate seal survival rates from the time of tagging to age 1 at all locations using the ratio of seals alive in the second year to number of pups tagged. These survival rates among the islands, from weaning to age 1, averaged over the years of the study, ranged from 0.80 to 0.90. For young seals over age 1, capture-recapture methods were used to calculate survival pooled through several years, and these rates ranged from 0.85 to 0.98. At French Frigate Shoals and Laysan Island, the higher numbers of tagged pups allowed separate estimates of male and female survival to be calculated. These rates suggested that survival of immature females was better than males. Beginning in 1989, survival of immature seals at French Frigate Shoals declined sharply.

Grigg, R. W. 1994. Precious coral fisheries of Hawaii and the U.S. Pacific Islands. *In* G.W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):50-60.

The precious coral fishery in Hawaii and the Western Pacific consists of one industry but two distinct and separate fisheries. The first is the harvest of black coral by scuba divers from depths of 30-100 meters (m). The second is a fishery for pink and gold coral at depths between 400 and 1500 m and employs either a human-operated submersible that permits selective harvest or tangle net dredges, which are nonselective. The modern history of these fisheries date from 1958 to the present. In this paper the ecology, life history, and management of the dominant species that make up these fisheries are reviewed. Research needs of the fisheries and the economic and future prospects of the precious coral industry are also described. At present, the precious coral jewelry industry in Hawaii (all species) is valued at about $25 million at the retail level.

Haight, W. R., D. R. Kobayashi, and K. E. Kawamoto. 1994. Biology and management of deepwater snappers of the Hawaiian Archipelago. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):20-27.

Commercial and recreational deepwater (100-400 meters) bottomfishing in Hawaii targets a multispecies group of lutjanid snappers. Relatively little is known about the life history of these species. Research in Hawaii and elsewhere in the tropical Pacific suggests that most of the species are slow growing, long lived, and have a relatively high age at sexual maturity. Stock assessment is difficult because of the multispecies nature of the fishery. However, recent analysis of commercial fishery data indicates that some of the species may currently be overexploited. Research is under way to determine the efficacy of management measures such as minimum-size limit changes or seasonal and spatial fishery closures to maintain optimal spawning biomass.

Hamm, D. C. 1994. The western Pacific fishery information network: a fisheries information system. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):102-108.

The Western Pacific Fishery Information Network (WPACFIN) is an intergovernmental agency cooperative program sponsored by the National Marine Fisheries Service (NMFS) to help participating island fisheries agencies carry out data collection, analysis, reporting programs, and data management activities to better support fisheries management under the Magnuson Fishery Conservation and Management Act and to help meet local fisheries information and management needs. The WPACFIN is the central source of information for Federal fisheries management of most fisheries in American Samoa, Guam, and the Northern Mariana Islands, and it plays an important role in acquiring fisheries data in Hawaii. This paper describes the development and status of this fishery information system.

Hensley, R. A., and T. S. Sherwood. 1994. An overview of Guam's inshore fisheries. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):129-138.

Guam's nearshore reef fishery is a multigear, multispecies fishery that has undergone major changes through the years. Methods have evolved and become

more modern. This, along with the changing economic status of Guam, has severely stressed the fishery. Top-targeted species are being overexploited and "growth harvesting" is occurring; the more serious form of "recruitment overharvesting," is happening to some of the key species. Major management concerns are discussed with respect to overfishing and habitat destruction. Management recommendations for this fishery include gear restrictions, size restrictions, and the establishment of marine conservation areas.

Hiruki L. M., W. G. Gilmartin, B. L. Becker, and I. Stirling. 1993. Wounding in Hawaiian monk seals (*Monachus schauinslandi*). Can. J. Zool. 71:458-468.

Injuries observed on endangered Hawaiian monk seals (*Monachus schauinslandi*) at Laysan Island and French Frigate Shoals in the Northwestern Hawaiian Islands in 1988-89 were classified into six major types based on the source of the wounds: mating attempts by adult male monk seals; nonmating aggressive interactions with other seals; attacks by large sharks; attacks by cookiecutter sharks (*Isistius brasiliensis*); contact with coral reef or debris; and entanglement in netting or marine debris. At both locations, injuries inflicted by adult male seals during mobbing incidents, in which many males attempt to mate with one seal, were seen more frequently than other types of injuries in 1988-1989. Injury data from 1982-1987 at Laysan Island and from 1985-1989 at French Frigate Shoals were used to compare the distribution of mating injuries inflicted by adult males and injuries inflicted by large sharks over size and sex classes of seals. Mating injuries caused by adult male seals were seen primarily on adult females but were also seen on seals in other size classes. Mating injuries inflicted by adult males occurred earlier in the year and with higher frequency at Laysan Island than at French Frigate Shoals. Injuries inflicted by large sharks were observed more often on adult male seals than on seals in other size classes at Laysan Island; however, no such difference was seen among size classes at French Frigate Shoals.

Hiruki, L. M., I. Stirling, W. G. Gilmartin, T. C. Johanos, and B. L. Becker. 1993. Significance of wounding to female reproductive success in Hawaiian monk seals (*Monachus schauinslandi*) at Laysan Island. Can. J. Zool. 71:469-474.

The researchers studied reproductive rate, length of lactation period, pup survival, and mortality of injured and uninjured female Hawaiian monk seals (*Monachus schauinslandi*) on Laysan Island, northwestern Hawaiian Islands, in 1983-1989. The severity and timing of nonfatal injuries were influential in determining their effect on female reproductive success. There was a tendency toward a shorter mean lactation period and lower survival rate of pups for females with major injuries than for uninjured females. Females with minor injuries were similar to uninjured females in terms of reproductive rate, length of lactation, and pup survival. For females injured shortly before the birth of their pup or during lactation, pup survival was lower than for uninjured females, whereas for females injured during the year prior to pupping, measures of reproductive success were not significantly different from those for uninjured females. Immature females (aged 4-8 years) entering the reproductive population were injured by adult male seals significantly more often than younger females aged 0-3 years but at a similar rate to adult females. The major effect of injuries on female reproductive success is an increase in female mortality: 87.5 percent of the adult females ($n = 16$) that died on Laysan Island in 1983-1989 sustained injuries from adult male seals.

Hobson, E. S. 1994. Ecological relations in the evolution of acanthoptergian fishes of warm-temperate communities of the northeastern Pacific. Environ. Biol. Fishes 40:49-90.

This paper relates the mixture of tropical and temperate species representing acanthopterygian fishes in northeastern Pacific communities to the influence of ecological relations on teleostean evolution. Most of the dominant forms have closer relatives mainly to the south, including labroid perciforms of the families Pomacentridae, Labridae and Embiotocidae. These are products of divergences from the teleostean mainstream that developed with the expansion of coral reef communities early during the Cenozoic Period. Those with closer relatives mainly to the north, including scorpaenoid, hexagrammoid and cottoid scorpaeniforms, pleuronectid pleuronectiforms, and zoarchoid perciforms, are products of divergences from the tropical mainstream that, being without obligate ties to coral reefs, were able to develop at higher latitutudes. That the tropical derivatives currently dominate in the warm-temperate communities can be attributed to effects of surface currents on early life history stages in this coastal upwelling system.

Ito, R. Y., D. R. Hawn, and B. B. Collette. 1994. First record of the butterfly kingfish *Gasterochisma melampus* (Scombridae) from the North Pacific Ocean. Japan. J. Ichthyol. 40(4):482-486.

Jacobson, L. D., and J. R. Hunter. 1993. Bathymetric demography and management of Dover sole. N. Am. J. Fish. Manage. 13(2):405-420.

Jefferson, T. A., A. C. Myrick, Jr., and S. J. Chivers. 1994. Small cetacean dissection and sampling: A field guide. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-198, 54 p.

Dissection and sampling techniques for small cetaceans are described for the standardization of the collection of biological data. Standardized data is important because it can be used to describe the natural history of a species, as well as to estimate life history parameters, age and sex structure of the fishery take and to determine population structure. Step-to-step procedures for taking external measurements and collecting samples are described in detail together with

illustrated diagrams and photographs. Storage methods and recommended preservatives for tissue samples are also presented. Sample data sheets used by the National Marine Fisheries Service, Southwest Fisheries Science Center and Southwest Region are also included in the field guide.

Johanos, T. C., B. L. Becker, and T. J. Ragen. 1994. Annual reproductive cycle of the female Hawaiian monk seal (*Monachus schauinslandi*). Mar. Mamm. Sci. 10(1):13-30.

Lenarz, W. H. 1994. Estimation of weight-length relationships from group measurements. Fish. Bull., U.S. 92(1):198-202.

Lenarz, W. H. 1993. Overview of the groundfish fisheries of the west coast of the United States of America. *In* 12ª Semana Das Pescas Dos Açores, 16 a 20 de Marco, Horta-Faial, Relatorio 1992, p. 215-219.

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard. 1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-206, 15 p.

MacCall, A. D., and K. Tatsukawa. 1994. Theoretical effects of habitat selection on distribution and productivity of whales. Rep. int. Whal. Commn. 44:407-411.

Biogeographic production models incorporating density-dependent habitat selection show that habitat selection behavior by whales could cause population per capita growth rate curves, $r(N)$, to be concave ($r''>0$) rather than convex ($r''<0$). This result influences both the location of the maximum sustainable yield (MSY) level relative to carrying capacity (MSYL/K) and MSY rate relative to maximum per capita growth rate ($r(0)$). This result occurs despite strong convexity ($r''<0$ for $0<N<K$) holding true at every location within the population. The true extent or influence of density-dependent habitat selection in whale populations is unknown. Theoretical models with habitat selection are able to produce a wide variety of plausible population growth curves. Monitoring growing whale populations provides the best evidence for the shape of growth curves and estimation of MSY rate. This study shows that observations must cover the full geographic range of the population. If there is evidence of increasing occupation of peripheral habitat with increasing abundance, habitat selection is likely to influence the shape of the growth curve, so that MSYL/K and MSY rate/$r(0)$ are lower than would otherwise be expected.

Mangels, K. F., and T. Gerrodette. 1994. Report of cetacean sightings during a marine mammal survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* July 28 - November 2, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-200, 74 p.

The primary objective of this marine mammal cruise conducted from July 28 to November 2, 1992, aboard the NOAA research vessel *McArthur* and *David Starr Jordan* was to survey the area inhabited by the central stock of common dolphins and to make an estimate of its absolute abundance to assess the impact of the dolphins killed by the U.S. and international yellowfin tuna fleet in the eastern tropical Pacific Ocean. The 670,102-square-nautical-mile survey area off the coast of Central America was covered by a systematic grid survey which began at the coastline of Columbia and ended at the Mexico-Guatemala border. Data was collected to estimate the density, size, and species composition of all dolphin and whale aggregations encountered to make estimates of their population sizes. Physical, biological, and oceanographic data regarding the habitat of marine mammals was also collected to better understand cetacean distribution patterns. A total of 1,360 cetacean sightings were made during the survey. This report includes figures showing grid tracklines and locations of sightings and tables which include time, position, and estimated school size of all sightings listed by species.

Moffitt, R. B. 1994. Pearl oysters in Hawaii. Hawaiian Shell News. 42(4):3-4.

Myers, R. F. 1994. Guam's small-boat-based fisheries. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):117-128.

Recent trends in Guam's small-boat fisheries and current knowledge of their biology, management, and economics are summarized. Annual estimates of participation, effort, and harvest are given for the pelagic and bottomfish fisheries for 1980-91 and for the spearfishing and atulai fisheries for 1985. The pelagic fishery is the largest, with annual landings ranging from 168 to 364 metric tons (t), followed by the bottomfish fishery (14-43 t), spearfishing fishery (5-17 t), and bigeye scad fishery (3-20 t). All the pelagic species are highly migratory and require regional management. They are heavily exploited by Guam-based domestic purse seine and foreign longline fisheries, but region-wide catch and effort as well as the status of stocks are largely unknown. Bottomfish and reef-fish stocks are shared to an unknown extent with those of the northern Marianas and are locally manageable. Certain vulnerable species of bottomfishes and reef fishes are overfished. Bottomfish and speared fish landings are dominated by small species with high turnover rates.

Nitta, E. T., and J. R. Henderson. 1994. A review of interactions between Hawaii's fisheries and protected species. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):83-92.

Several fisheries in Hawaii are known to have interactions with protected cetaceans, seabirds, marine turtles, or seals. Handline fisheries for bottomfish, tuna, and mackerel scad lose bait and catch to bottlenose

dolphins, rough-toothed dolphins, albatrosses, and boobies; these fisheries may also lose catch to false killer whales. A longline fishery for tuna and billfish has burgeoned in Hawaii since 1987, resulting in interactions with protected species. Marine turtles, seabirds, and monk seals take bait and are known to become hooked, and false killer whales may take catch. Research on deterrents or alternative fishing methods has been limited, and interactions have been reduced primarily through management and regulatory actions. These include area closures and gear requirements. An observer program has also been established for the bottomfish and longline fisheries.

Norton, J. G., D. R. Cayan, and D. R. McLain. 1994. Near and distant connection of atmospheric systems to ocean temperature change in the coastal California Current region. *In* K. T. Redmond, and V. L. Tharp (eds.), Proceedings of the Tenth Annual Pacific Climate (PACLIM) Workshop, April 4-7, 1993. California Department of Water Resources, Interagency Ecological Studies Program Report 36.

Time series of ocean temperature change in the California Current region for the spring-summer warming period complement earlier studies which focused on the fall-winter ocean cooling season. Connections between interannual fall-winter temperature changes in the coastal California Current region and two widely separated locales of atmospheric forcing (North Pacific and equatorial Pacific) have been established. Forcing during the spring-summer period appears similar. The two seasonal series sets are compared to environmental anomalies and changes that have already been reported in the scientific literature. Comparison of the earlier reports detailing extreme events which occurred in the 1954-86 period to the ocean temperature series allows the various environmental events to be compared even though the original data showing event intensity and duration is widely different. The newly developed series also allow some understanding of event-forcing mechanisms to be derived from the oceanic response. The full ocean temperature change series are compared to atmospheric pressure fluctuations over the North Pacific north of 20° N.

Okechi, J. K., and J. J. Polovina. 1994. The spiny lobster fishery of Kenya. *In* B. F. Phillips, J. S. Cobb, and J. Kittaka (eds.), Spiny Lobster Management, pp. 103-107. Blackwell Scientific Publications, Ltd., Cambridge, MA.

Oliver, C. W., W. A. Armstrong, and J. A. Young. 1994. Development of an airborne LIDAR system to detect tunas in the eastern tropical Pacific purse-seine fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-204, 67 p.

Parrish, F. A., and J. J. Polovina. 1994. Habitat thresholds and bottlenecks in production of the spiny lobster (*Panulirus marginatus*) in the Northwestern Hawaiian Islands. Bull. Mar. Sci. 54(1):151-163.

Pearcy, W. G., J. P. Fisher, and M. M. Yoklavich. 1993. Biology of the Pacific pomfret (*Brama japonica*) in the North Pacific Ocean. Can. J. Fish. Aquat. Sci. 50:2608-2625.

Abundance of Pacific pomfret (*Brama japonica*), an epipelagic fish of the North Pacific Ocean, was estimated from gillnet catches during the summers of 1978-89. Two size modes were common: small pomfret <1 year old, and large fish ages 1-6. Large and small fish moved northward as temperatures increased, but large fish migrated farther north, often into the cool, low-salinity waters of the Central Subarctic Pacific. Lengths of small fish were positively correlated with latitude and negatively correlated with summer surface temperature. Interannual variations in the latitude of catches correlated with surface temperatures. Large catches were made in the eastern Gulf of Alaska (51°-55° N) but modes of small pomfret were absent here, and large fish were rare at these latitudes farther to the west. Pomfret grow rapidly during their first 2 years of life. They are pectoral fin swimmers that swim continuously. They prey largely on gonatid squids in the region of the Subarctic Current in the Gulf of Alaska during summer. No evidence was found for aggregations on a scale ≤1 kilometer. Differences in the incidence of tapeworm, spawning seasons, and size distributions suggest the possibility of discrete populations in the North Pacific Ocean.

Pitman, R. L. 1993. Seabird associations with marine turtles in the eastern tropical Pacific. Colonial Waterbirds 16(2):194-201.

Polovina, J. J. 1994. The lobster fishery in the Northwestern Hawaiian Islands. *In* B. F. Phillips, J. S. Cobb, and J. Kittaka (eds.), Spiny Lobster Management, p. 83-90. Blackwell Scientific Publications, Ltd., Cambridge, MA.

———————. 1994. The lobster and shrimp fisheries in Hawaii. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):28-33.

A description of the lobster and deepwater shrimp fisheries in Hawaii is presented, addressing harvest levels, biology, and research. Both fisheries are trap fisheries. The lobster fishery is a limited entry fishery with 1991 landings of 200 metric tons. The shrimp fishery is unregulated, with very sporadic effort, and annual landings below 200 metric tons.

Pooley, S. G. 1994. Economics and Hawaii's marine fisheries. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):93-101.

This paper is a review of economic research conducted on Hawaii's marine fisheries over the past 10 years. The fisheries development and fisheries management context for this research is also considered. The author finds that new approaches are required for marine fisheries research in Hawaii: a wider scope to include

other marine resource and coastal zone issues and increased and closer collaboration between researcher and the fishing community.

————————. 1994. Hawaii's marine fisheries: some history, long-term trends, and recent developments. *In* G. W. Boehlert (ed.), The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2):7-19.

The author provides an overview of Hawaii's marine fisheries from 1948 to the present. After 3 decades of decline following a brief period of growth at the conclusion of World War II, Hawaii's commercial fisheries began a decade of sustained development in the 1980s. At the same time, fisheries management issues became more significant as different segments of the fishery came into more direct competition. Pooley provides new estimates of commercial landings for the 1977-90 period and summarizes limited information on recreational and subsistence fisheries in the 1980s. It also provides some historical context which may be useful in evaluating fishery development and management options.

Russell, D. J., and G. H. Balazs. 1994. Colonization by the alien marine alga *Hypnea musciformis* (Wulfen) J. Ag. (Rhodophyta: Gigartinales) in the Hawaiian Islands and its utilization by the green turtle, *Chelonia mydas*. L. Aquat. Bot. 47:53-60.

In Hawaii, the alien red alga *Hypnea musciformis* (Wulfen) J. Ag. was originally planted on reefs in Kaneohe Bay, Oahu, in January 1974, but has since spread to many other locations on Oahu and to other Hawaiian islands. This alga, along with the previously introduced alien seaweed *Acanthophora spicifera* (Vahl) Boerg. is now being prominently used as a food source by the green turtle (*Chelonia mydas* L.) in the Hawaiian Islands. This is the first known documentation of introduced algae being incorporated into the diet of the green turtle, a species considered endangered worldwide.

Seki, M. P., and D. A. Somerton. 1994. Feeding ecology and daily ration of the pelagic armorhead, *Pseudopentaceros wheeleri*, at Southeast Hancock Seamount. Environ. Biol. Fishes 39:73-84.

Smith, M. K. 1994. An ecological perspective on inshore fisheries in the main Hawaiian Islands. *In* G.W. Boehlert (ed.), The fisheries of Hawaii and U.S.- associated Pacific Islands. Mar. Fish. Rev. 55(2):34-49.

A description of fisheries within a depth of 100 fathoms is provided for the eight southeastern-most islands of the Hawaiian Archipelago, known as the main Hawaiian Islands (MHI), which, because they are inhabited, are subject to inshore fishing pressure due to their accessibility. The majority of this review, which covers 1980-90, is based on reported commercial landings. The principal ecological factors influencing fisheries in the MHI are also listed, as are negative human impacts on inshore reef ecosystems.

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Squires, D. 1994. Firm behavior under input rationing. Journal of Econometrics 61:235-257.

————1994. Sources of growth in marine fishing industries. Marine Policy 18(1):5-18.

Approved by Science and Research Director, SWR

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Balazs, G. H., W. C. Dudley, L. E. Hallacher, J. P. Coney, and S. K. Koga. Ecology and cultural significance of sea turtles at Punalu'u, Hawaii. For consideration for publication in Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation.

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DiNardo, G. T., and W. W. H. Kwok. Estimates of fish and cephalopod catch in the North Pacific high-seas driftnet fisheries, 1990-91. For consideration for publication in Technical Report NMFS.

Dizon, A. E., C. A. LeDuc, and R. G. LeDuc. Intraspecific structure of the northern right whale dolphin (*Lissodelphis borealis*): the power of an analysis of molecular variation for differentiating genetic stocks. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

Fiedler, P. C. Seasonal and interannual variability of CZCS phytoplankton pigments and winds in the eastern tropical Pacific. For consideration for publication in Journal of Geophysical Research.

Finn, M. A., and M. R. Rice. Hawaiian monk seal observations at Necker Island, 1993. For consideration for publication in 'Elepaio.

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Hobson, E., and J. Chess. Trophic relations among acanthopterygian fishes and benthonic organisms in southern California marine communities. For consideration for publication in Technical Report NMFS.

Hopkins, T. E., M. B. Eldridge, and J. J. Cech, Jr. Metabolic costs of viviparity in yellowtail rockfish, *Sebastes flavidus*. For consideration for publication in Environmental Biology of Fishes.

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Norton, J. G., and S. J. Crooke. Occasional availability of dolphin, *Coryphaena hippurus*, to southern California commercial passenger fishing vessel anglers: observations and hypotheses. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

Pearson, D. E. Sexual, geographical, and annual differences in the timing of annuli formation in otoliths of the widow rockfish (*Sebastes entomelas*). For consideration for publication in Fishery Bulletin, U.S.

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Wetherall, J. A., and G. H. Balazs. Trends in the green turtle nesting colony at French Frigate Shoals, Northwestern Hawaiian Islands. For consideration for publication in Marine Ecology Progress Series.

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Yoklavich, M. M., G. M. Cailliet, H. G. Greene, and D. Sullivan. Interpretation of sidescan sonar records for rockfish habitat analysis: examples from Monterey Bay. For consideration for publication in Alaska Department of Fish and Game, Special Publication Series.

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Administrative Reports are strictly for internal use only and are not to be cited or treated as publications.

La Jolla, California

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Arenas, P., T. J. Barnes, and L. D. Jacobson. 1994. Fishery and biological data for northern anchovy taken in Mexican waters, 1978-1989. SWFSC Admin. Rep., La Jolla, LJ-94-03, 24 p.

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Tillman, M.F. 1994. Director's Report to the 45th Tuna Conference on tuna and tuna-related activities at the Southwest Fisheries Science Center for the period May 1, 1993, to April 30, 1994. SWFSC Admin. Rep., La Jolla, LJ-94-05, 29 p.

Armstrong, W. A. 1994. Revised and edited field notes 1993 dolphin-tuna tracking study 6 November 1993 - 5 December 1993. SWFSC Admin. Rep., La Jolla, LJ-94-06, 38 p.

Perkins, C. P., and E. F. Edwards. 1994. A mixture mode for estimating bycatch from data with many zero observations: Tuna bycatch in the eastern tropical Pacific Ocean. SWFSC Admin. Rep., La Jolla, LJ-94-07, 28 p.

Jacobson, L.D., E. Konno, and J.P. Pertierra. 1994. Status of Pacific mackerel and trends in abundance during 1978-1993 (with data tables). SWFSC Admin. Rep., La Jolla, LJ-94-08, 32 p.

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Mackett, D., L. Jacobson, A. MacCall, S. Pooley, W. Silverthorne, D. Squires, and C. Thomson. 1994. A plan for establishing a system to deliver sociological and cultural information to support fishery management, recovery of protected species, and coastal ecosystem health. SWFSC Admin. Rep., La Jolla, LJ-94-10, 16 p.

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